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Volume 2 *1988-1989*

Chinese Herpetological Research

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Cover: *Phrynocephalus axillaris*, from Dunhuang, Jiuquan Prefecture, Gansu Province, China.

CHINESE HERPETOLOGICAL RESEARCH

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A New Species of *Rana* from Ningxia Hui Autonomous Region

ERMI ZHAO[1], J. ROBERT MACEY[2] AND THEODORE J. PAPENFUSS[2]

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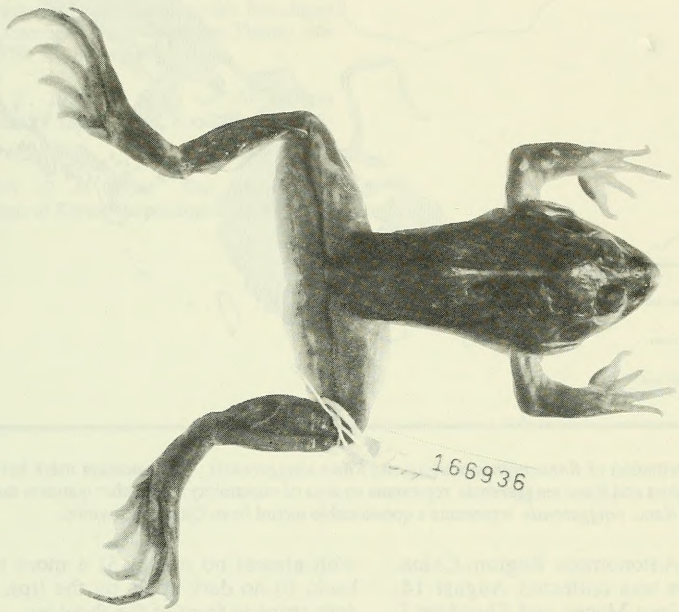

FIG. 1. Holotype CIB 80001 - CAS 166936 of *Rana tenggerensis*

Two specimens of *Rana* were collected during the joint 1987 Chengdu Institute of Biology and University of California Expedition to the deserts of northern China. They were found along the banks of the Yellow River (Huang He) where it flows along the edge of the Tengger Desert in Ningxia Hui Autonomous Region. Both specimens were collected after dark in pools along the banks of the river. Upon examination of these specimens we determined that they represent an undescribed species (Fig.1). This species, named after the Tengger Desert, is closely related to *Rana nigromaculata* Hallowell. Figure 2 shows the distribution of both forms. The distribution shown for *Rana nigromaculata* was compiled from Dixon (1956), Lui (1950), Lui & Hu (1961), Moriya (1955), Okada (1927), Kawamura & Nishioka (1979), Shannon (1956), and Bannikov (1977). The nomenclature used follows that of Kawamura & Nishioka (1979).

Rana tenggerensis sp. nov.

Holotype: CIB 80001 - CAS 166936, an adult male from along the north shore of the Yellow River (Huang He), at Shapotou Desert Research Station, Shapotou (37° 30'N 104° 58'E), Yinnan Prefecture,

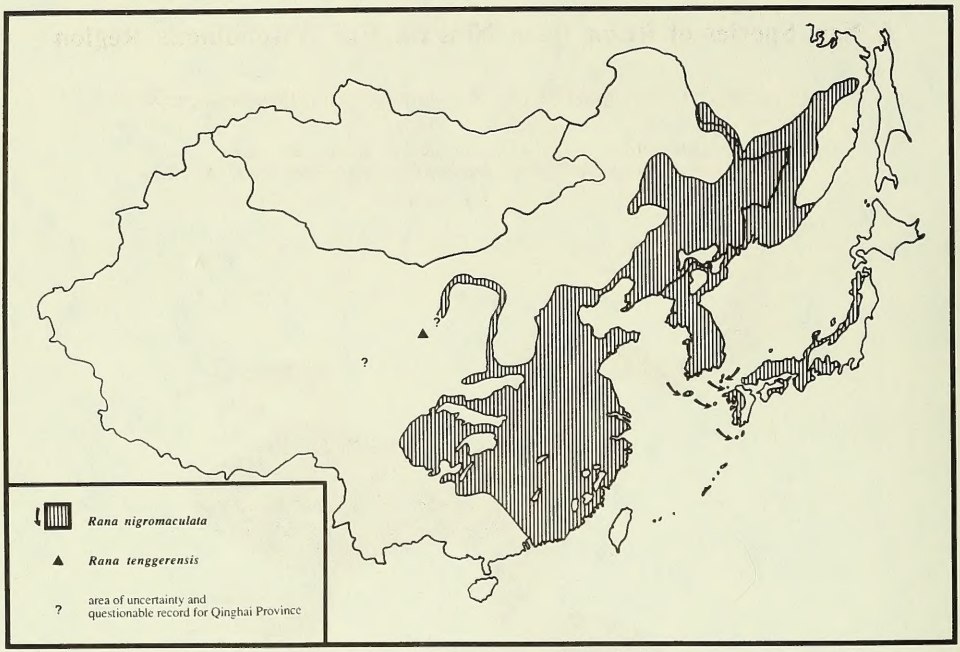

FIG. 2. The distribution of *Rana nigromaculata* and *Rana tenggerensis*. The question mark between *Rana nigromaculata* and *Rana tenggerensis* represents an area of uncertainty. The other question mark to the southwest of *Rana tenggerensis* represents a questionable record from Qinghai Province.

Ningxia Hui Autonomous Region, China. The specimen was collected August 14, 1987 by J. Robert Macey and Theodore J. Papenfuss. The Holotype is deposited at the Chengdu Institute of Biology.

Paratype: CAS 166808, an adult male from along the south shore of the Yellow River (Huang He), at Shenjiatan (37° 28' N 105° 18' E), Yinnan Prefecture, Ningxia Hui Autonomous Region, China. The specimen was collected August 13, 1987 by J. Robert Macey and Theodore J. Papenfuss. The specimen is deposited at the California Academy of Sciences.

Diagnosis: This new form, *Rana tenggerensis*, is a close relative of *Rana nigromaculata* Hallowell, but differs from the latter in having 1) a wider head, 2) the nostril closer to the eye than to the tip of the snout, 3) the tibia to snout-vent length proportionally shorter, 4) full webbing with almost no notch, 5) a more rugose back, 6) no dark spots on the lips, 7) no dark stripe in front of the shoulder.

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The Snakes of Ningxia Hui Autonomous Region as an Indication of a Herpetofaunal Corridor

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Few herpetological expeditions have made collections in Ningxia Hui Autonomous Region and the snake fauna is poorly known. Only two species, *Psammophis lineolatus* and *Agkistrodon intermedius* have been reported (Tian & Jiang 1986). A live specimen of *Agkistrodon strauchii* was examined by the third author at Zhejiang Medical University in Hangzhou. It was said to have come from the Liupan Mountains. During the joint 1987 Chengdu Institute of Biology and University of California Expedition to the deserts of northern China, three new snake records were obtained from Ningxia Hui Autonomous Region. The specimens were all collected along the north shore of the Yellow River (Huang He), at Shapotou Desert Research Station, Shapotou (37° 30' N 104° 58' E), Yinnan Prefecture, Ningxia Hui Autonomous Region, China.

The three species we found at Shapotou are *Coluber spinalis*, *Elaphe dione* and *Rabdophis tigrina lateralis*. The *Coluber spinalis* was found in a bush in an area of low, rolling sand dunes adjacent to the Yellow River. It was active during the late morning in an area where *Phrynocephalus przewalskii* were very abundant. The specimens of *Elaphe dione* and *Rabdophis tigrina lateralis* were found in an area of cultivated fields near the river.

This site is located at the edge of the sandy Tengger Desert. In this area the Yellow River begins to broaden into an interior delta after passing through a rocky stretch with little vegetation. Here the river flows north-northeast looping through the Gobi Desert and finally flowing south and east to northeastern China (Fig.1).

As the Yellow River descends in altitude from the Tibetan Plateu, the annual rain fall decreases from 500 - 750 mm to 100 - 250 mm in the Gobi Desert loop of the river. Following the Yellow River upstream from the Pacific Coast, the same effect occurs. Annual precipitation drops from 500 - 750 mm to 100 - 250 mm. Subsequently the Gobi Desert loop of the Yellow River provides a mesic connection from the Tibetan Plateu across the arid Gobi Desert to the coastal region of northeastern China. This connection provides a route for dispersal of mesophilic species.

Two of the snake species reported here, *Elaphe dione* and *Rabdophis tigrina lateralis*, follow this corridor. The direction of dispersal for *Elaphe dione* cannot be inferred to be from northeastern China, because of its occurrence from the Black Sea in Europe across the USSR (Bannikov et al. 1977), Mongolia, and much of northern China. *Bufo raddei* uses the Yellow River as a mesic refuge in the same manner as *Elaphe dione* and also occurs widely to the northeast and west of the Gobi Desert loop of the Yellow River. The distribution of these two species in northern China is similar in that both species have their coastal southern distributional limits in Jiangsu Province (Tien and Jiang 1986). *Rabdophis tigrina laterals* enters the Gobi Desert by way of the Yellow River. Its overall distribution is throughout eastern China except the tropical south. Another example of the use of the Yellow River as a corridor is found in frogs of the *Rana nigromaculata* species group which also are distributed mainly in eastern China except the tropical south. The outlying species occurring in the Ningxia Hui Autonomous Region is the recently described *Rana tenggerensis* (Zhou et al. 1988). It is interesting to note that both *Rabdophis tigrina* and *Rana nigromaculata* share

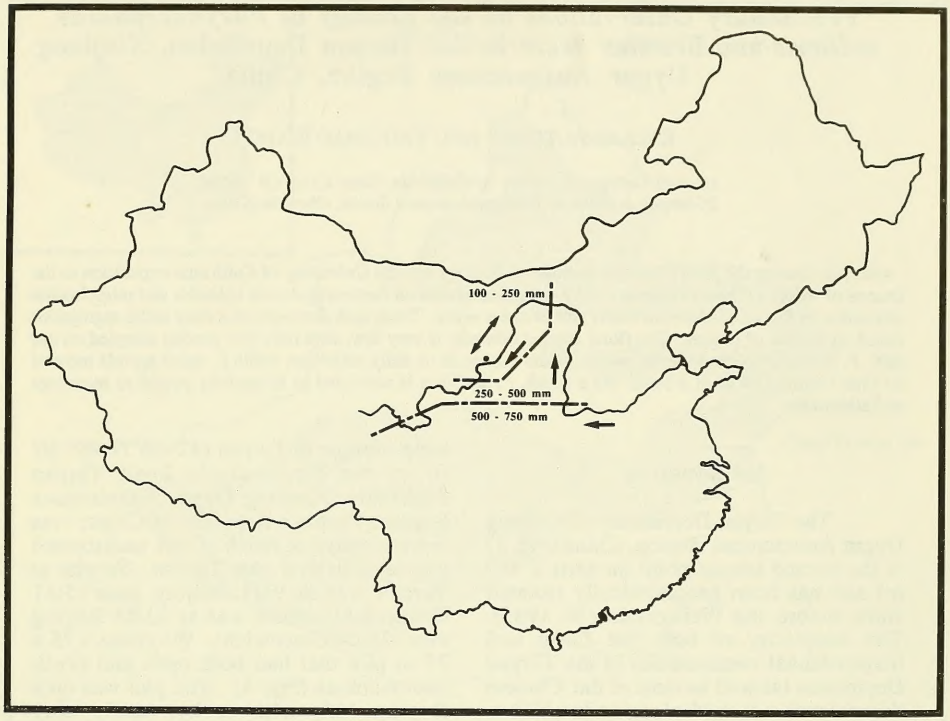

FIG. 1. The location of the Yellow River of China with approximate rainfall contours to illustrate the aridity of the Gobi Desert loop. The location of Shapatou is represented by a dot. The arrows show possible uni- and bi-directional dispersal routes along the corridor.

further similarity in distribution and occur in Korea, Japan, and the southern Pacific coastal region of the USSR. The other species of snake reported here, *Coluber spinalis*, does not follow the Yellow River into the Gobi Desert. It is a wide-ranging species in northern China that can be found in both mesic and xeric conditions (Pope 1935).

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Preliminary Observations on the Ecology of *Phrynocephalus axillaris* and *Eremias velox* in the Turpan Depression, Xinjiang Uygur Autonomous Region, China

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Abstract.-During the joint Chengdu Institute of Biology and the University of California expedition to the deserts of western China in Summer 1987 we gathered data on thermoregulatory behavior and microhabitat utilization in *Phrynocephalus axillaris* and *Eremias velox*. These data demonstrate a clear niche segregation based on the use of bushes. The floral species diversity is very low, with only two species sampled on our site. *P. axillaris* seems to make no use of the bushes in its daily activities, while *E. velox* spends most of its time within 0.04 m of a bush. As a result, *P. axillaris* is restricted in its activity period to mornings and afternoons.

Introduction

The Turpan Depression of Xinjiang Uygur Autonomous Region, China (Fig. 1) is the second lowest point on earth (-150 m) and has been geographically isolated since before the Pleistocene (Xi 1985). The simplicity of both the floral and herpetofaunal communities in the Turpan Depression (as well as most of the Chinese deserts) makes it an ideal region in which to study lizard ecology. While participating in a cooperative expedition between the Chengdu Institute of Biology, Academia Sinica, China, and the University of California, USA, in the summer of 1987, we recorded some preliminary ecological data on *Phrynocephalus axillaris* (Agamidae) (Fig. 2) and *Eremias velox* (Lacertidae) (Fig. 3) at a site near the town of Turpan. *Teratoscincus scincus* (Gekkonidae) and *Psammophis lineolatus* (Colubridae) were also present on the site. The logistics of the expedition prevented us from sampling over a longer period of time, so our data are not by any means representative and should be interpreted only as a single sample in time and space. To the best of our knowledge, this is the first study in desert lizard ecology in the People's Republic of China.

Methods

The study site, 4.4 km west of the main mosque in Turpan (42° 56' N 89° 10' E) on the Turpan-Jiaohe Road, Turpan Prefecture, Xinjiang Uygur Autonomous Region, People's Republic of China, was representative of much of the undisturbed vegetated habitat near Turpan. Sunrise at Turpan was at 9:31 Beijing time (5:31 Greenwich); sunset was at 22:24 Beijing time (18:24 Greenwich). We chose a 75 x 75 m plot that had both open and brush microhabitats (Fig. 4). The plot was on a sloping hill, with rocky, sandy clay substrate. Using the line-intercept method (Brower and Zar 1984), we sampled the flora along two 75 m transects that trisected the plot, north to south. The transects were broken up into 15 m intervals. From 7 Sept., 1987 to 11 Sept., 1987, we repeatedly and systematically transected the site and sampled *P. axillaris* and *E. velox*. The lizards were noosed and their cloacal temperature recorded with a Fluke 25 heat-resistant multimeter with thermocouple transducer while still suspended from the noose and with hind leg grasped (Avery 1982) if no longer than 30 seconds had elapsed from the time of first sighting. They were sexed, measured, uniquely toe clipped and paint marked on the dorsal surface with nail polish, and released. We recorded the ground and air temperature, and the distance to the nearest bush from the area where the individual was first sighted. Daily recapture data allowed us to calculate a rough density estimate for both species, using the Schnabel method of

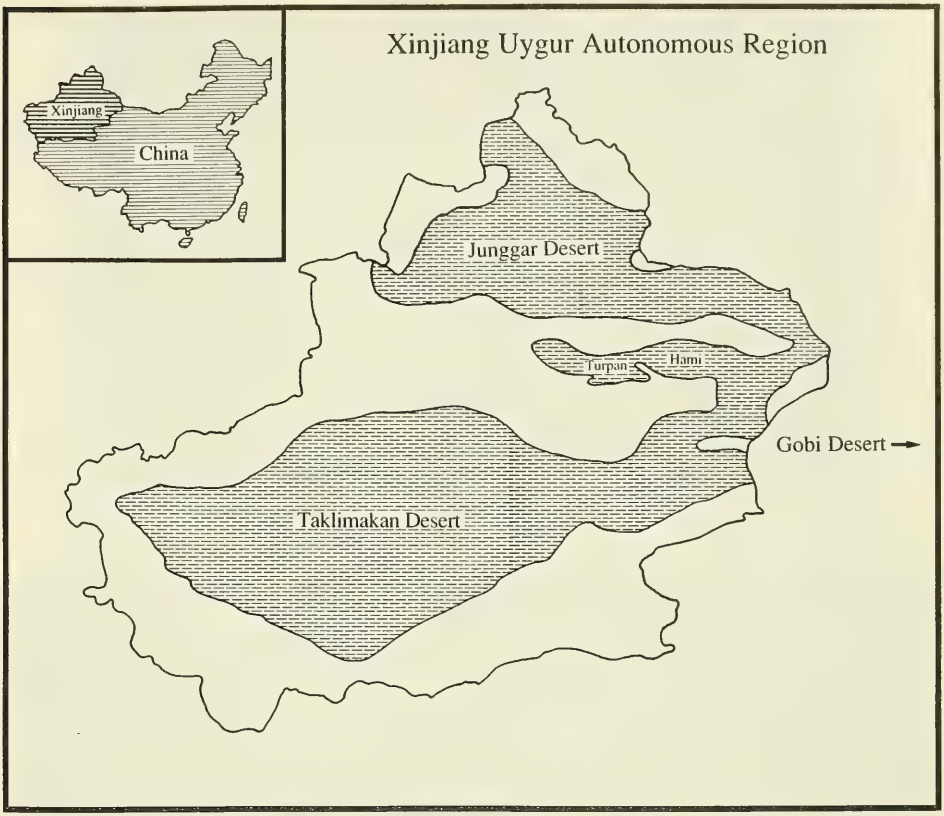

FIG. 1 Desert regions of western China.

mark-recapture sampling (Giles 1971; Schnabel 1938).

Results

1. Habitat.

Alhagi sparsiflora (Leguminosae) (Fig 5) was the only plant sampled on a 150 m line transect. Its frequency among fifteen 10 m intervals was 0.93. The density and coverage were 0.31 plants/m and 0.21, respectively. A plant of *Nitraria sp.* (Zygophyllacae) was rare on the site. Daytime air temperatures ranged from 24 to 45 °C.

2. Species interactions and behavior.

Eremias velox frequently move from bush to bush and forage most often in the shade. *Phrynocephalus axillaris* emerge from their burrows, which seem to all be in open ground, and remain motionless unless approached. Small rocks allow the lizards to orient with respect to the sun. *Phrynocephalus axillaris*.do not seem to make any use of the shade provided by the bushes. We observed intraspecific agonistic behavior in *E.velox*. In one case, an individual pursued another for over 20 m. Intra- and interspecific interactions were not evident in *P. axillaris*.

FIG. 2 *Phrynocephalus axillaris* at Turpan, Xinjiang Uygur Autonomous Region, China.

FIG. 3. *Eremias velox* at Turpan, Xinjiang Uygur Autonomous Region, China.

FIG. 4. (ABOVE) Study site at Turpan, Xinjiang Uygur Autonomous Region, China.
FIG. 5. (BELOW) *Alhagi sparsiflora*, the dominant plant at the Turpan study site, Xinjiang Uygur Autonomous Region, China.

Psammophis lineolatus were active in the early morning and late afternoon in the low, spiny branches of *A. sparsiflora*. One individual stayed motionless, without any contact with the substrate. This snake was very wary and retreated to its burrow when approached. The stomach contents of another specimen captured in a bush included a juvenile *E. velox*. *Teratoscincus scincus* were present in great number on the site. After sunset, these lizards emerge from their extensive burrows, contrary to Pianka's (1986) prediction that nocturnal lizards should not occur at such high latitudes. We also observed *Teratoscincus przewalskii* only after dark in the Taklimakan. Both species spend much of their time motionless, but frequently move several meters at a time, presumably foraging for invertebrates.

3. Habitat utilization and thermoregulation.

The mean distance to the nearest plant was significantly greater ($t = 8.65$, $DF = 87$, $\alpha = 0.05$) in *P. axillaris* (2.17 m, std. dev. 2.00) than in *E. velox* (0.04 m, std. dev. 0.10). There is not a significant linear relationship between body temperature and distance to the nearest plant in either *P. axillaris* or *E. velox* (Fig. 6&7). *P. axillaris* were active (on clear days) from 1:29 to 3:39 after sunrise and from 5:30 to 1:45 before sunset (11:00 to 13:10 and from 16:50 to 20:35 Beijing time). At the point of sighting, air temperatures ranged from 26.6 to 41.7 °C, and ground temperatures ranged from 29.6 to 42.0 °C. Body temperature vs. air temperature can be approximated by the linear equation, $BT = 16.78 + 0.60AT$ ($R2 = 0.58$, $t = 7.54$, $\alpha = 0.05$) (Fig. 8). Mean body temperature in *P. axillaris* was 36.8 °C (std. dev. 3.58) and ranged from 29.7 to 42.8 °C. *Eremias velox* were active (on clear days) from 1:24 after sunrise to 1:35 before sunset (10:55 to 20:45 Beijing time). Air temperatures ranged from 24.8 to 42.0 °C , and ground temperatures ranged from 24.7 to 44.7 °C. Body temperature vs. air temperature can be approximated by the linear equation, $BT = 19.94 + 0.53AT$ ($R2 = 0.67$, $t = 11.66$, $\alpha = 0.05$) (Fig. 9). Mean body temperature in adult *E. velox* was 38.4 °C (Std. Dev 2.94), and ranged from 26.3 (at emergence) to 43.5 °C. Juvenile *E. velox* seem to spend most of their time under dense cover; we were not able to effectively sample the juveniles.

4. Density.

Rough density estimates on the site are 66±11.49 (117/hectare) ($\alpha = 0.05$) for adult *E.velox*, and 18±2.56 (32/hectare) ($\alpha = 0.05$) for *P. axillaris*. *Psammophis lineolatus* were sighted 3 times during the study. A very rough density estimate obtained by eyeshining *T. scincus* is 30 individuals on the site.

5. Body size and evidence of predation.

Mean snout-vent length was 43 ±14 mm, and mean tail length was 66 ±21 mm in *P. axillaris*; 36% of these fall in the 45-49 mm range (Fig. 10). Mean snout-vent length was 59 ±12 mm, and mean tail length was 97 ±51 mm in *E.velox*; over 71% of these fall in the 55-64 mm range (Fig. 11). Twenty-nine out of 59 *E. velox* showed evidence of tail regeneration, with a mean regenerated tail length of 90 ±58 mm. There was no evidence of tail loss in *P. axillaris*.

Discussion

While our results are not unexpected, it is interesting to note that *Phrynocephalus* does not shun bushes throughout its range. In Korla, Xinjiang Uygur Autonomous Region (south of Turpan in the Taklimakan Desert), Dunhuang, Gansu Province (the extreme eastern Taklimakan Desert), and Shapotou, Ningxia Hui Autonomous Region (Central Gobi Desert), *Phrynocephalus* is found very close to and under bushes. *Eremias* were very rare in the area we sampled near Korla and it is possible that a greater microhabitat diversity may be available to *Phrynocephalus* in the absence of *Eremias*. The temperature, however, was much cooler when we were in Korla and the significance of a comparison of *P. axillaris* between Turpan and Korla is questionable at best. *P. axillaris* seems similar in form

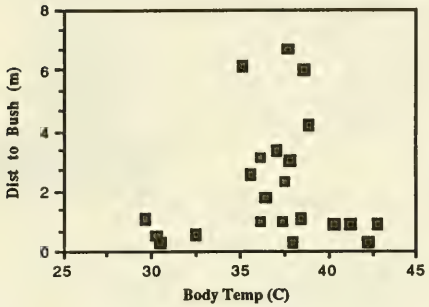

FIG. 6. Distance to the nearest bush vs. air temperature in *Phrynocephalus axillaris* at Turpan, Xinjiang Uygur Autonomous Region, China. *P. axillaris* were not found closer than 0.25m to a bush. There is no significant linear relationship between body temperature and distance to bush.

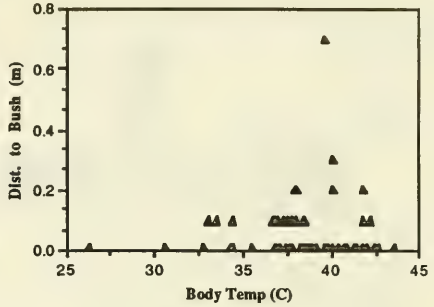

FIG. 7. Distance to the nearest bush vs. air temperature in *Eremias velox* at Turpan, Xinjiang Uygur Autonomous Region, China. *E. velox* were most often found in or close to bushes. There is no significant linear relationship between body temperature and distance to bush.

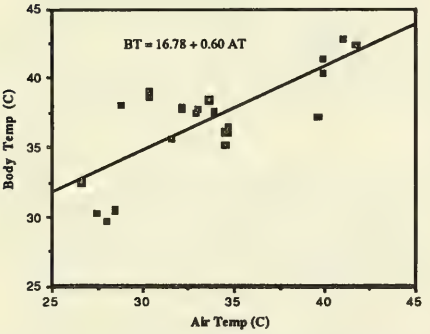

FIG. 8. Body temperature vs. air temperature in *Phrynocephalus axillaris* at Turpan, Xinjiang Uygur Autonomous Region.

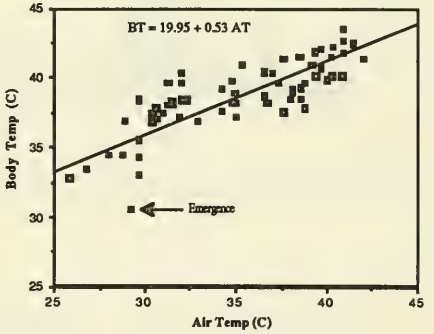

FIG. 9. Body temperature vs. air temperature in *Eremias velox* at Turpan, Xinjiang Uygur Autonomous Region, China. Arrow indicates an emergence temperature.

to *Callisaurus draconoides* (Iguanidae) and in behavior to *Phrynosoma platyrhinos* (Iguanidae) of North America. We observed another distinct behavioral type (that we term the "*Callisaurus*" type) in *Phrynocephalus przewalskii* at Wuwei, Gansu Province. These lizards were very wary and would flee for long distances if approached. They seemed to have a greater capacity for sustained activity than the *P. axillaris* of Turpan and Korla. *E. velox* seems similar to small *Cnemidophorus* (Teiidae) of North America. Mean body temperatures in *E. velox* (38.4 °C) are similar to those observed in the closely related *Pedioplanis lineoocelata* (38.4 °C) and *Pedioplanis namaquensis* (38.5 °C), which were formerly placed in the genus *Eremias* (Brattstrom 1965).

The activity period of *P. axillaris* is restricted to mornings and afternoons, and we conclude that this is related to the lizards' preference for open microhabitat.

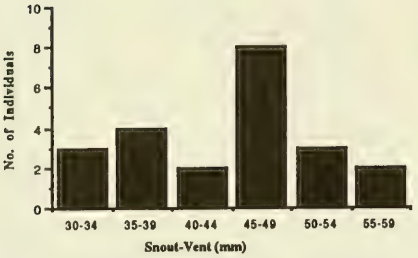

FIG. 10. Snout-vent frequency in *P. axillaris* at Turpan, Xinjiang Uygur Autonomous Region, China.

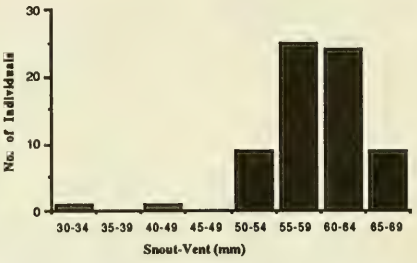

FIG. 11. Snout-vent frequency in *E. velox* at Turpan, Xinjiang Uygur Autonomous Region, China.

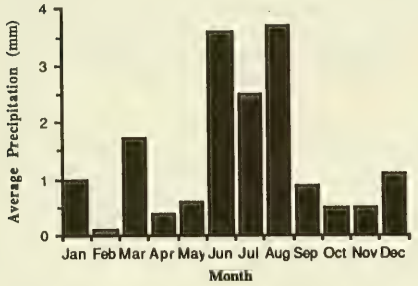

FIG. 12. Average monthly rainfall at Turpan, Xinjiang Uygur Autonomous Region, China.

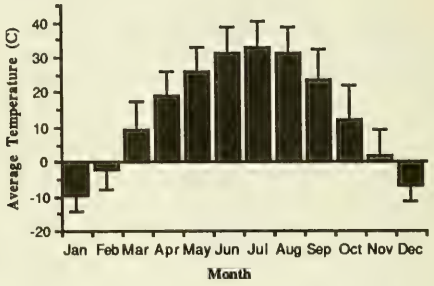

FIG. 13. Solid bars denote average daily air temperature for each month of the year at Turpan, Xinjiang Uygur Autonomous Region, China. Vertical lines above 0°C denote maximum average temperature; lines below 0°C denote minimum average temperature.

Eremias velox is able to actively thermoregulate and forage throughout the day. This lizard is a wide-forager, may be territorial, maintains a high density, and experiences a high degree of predation. *Psammophis lineolatus* and *T. scincus* are probably the primary predators, the latter foraging nocturnally above ground, and diurnally in burrows. *Psammophis lineolatus* probably preys more intensely on *E. velox* than on *P. axillaris* since it is associated with bushes, and since *E. velox* is a widely-foraging lizard and is more likely to be encountered by a sit-and-wait snake (Huey and Pianka 1981) The diet analysis of *Psammophis lineolatus* and *T. scincus* (J. R. Macey and Y. Z. Wang 1988 in prep.), as well as the small size of both predators suggest that most of the predation pressure is on juvenile *E. velox*. The lack of tail loss in *P. axillaris* is inconclusive since agamids do not easily autotomize their tails.

Mean annual rainfall (Fig. 12) at Turpan is 16.6 mm (Anon. undated), which contributes to the extremely low floral species diversity. Mean temperature exceeds 20°C only during a five-month period from April to September (Fig. 13). This probably limits the activity period of reptiles to five months or less.

We plan to expand our study to three sites in 1988: Shapotou, Ningxia Hui Autonomous Region in the Gobi Desert, a Taklimakan Desert site, as well as the Turpan site. This will allow us to compare

the thermal niche breadth and microhabitat selection in a manner similar to Grant and Dunham (1988) in *Eremias-Phrynocephalus* communities across the Chinese deserts. We also plan to investigate the behavioral differences in *Phrynocephalus* at the various regions in a physiological context.

Acknowledgements

We would like to thank Ermi Zhao of the Chengdu Institute of Biology (Academia Sinica, China) for support of the project. We also thank Theodore J. Papenfuss and J. Robert Macey of the Museum of Vertebrate Zoology (Univ. Calif. Berkeley) for editing, assistance in the field, and use of specimens, Margaret Fusari of the Univ. Calif. Santa Cruz for invaluable advice, Jonathan Losos of the Museum of Vertebrate Zoology (Univ. Calif. Berkeley) for last minute editing, Terry Horn of Scimitar Meats for the donation of gourmet beef jerky, and Zhang Zemin of the Chengdu Institute of Biology (Academia Sinica, China) for making our expedition run smoothly.

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CHINESE HERPETOLOGICAL RESEARCH

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A New Species of the Genus *Paramesotriton* (Amphibia: Caudata) from Guangxi and a Comparison with *P. guangxiensis*

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Abstract. -A new species of *Paramesotriton* is described from Guangxi Zhuang Autonomous Region. This species is characterized by tips of the fore limbs which exceed the anterior margin of the eyes to a greater extent and granular warts that are much more dense than observed in *P. guangxiensis*.

Key Words: Amphibia, Caudata, China, Guangxi, *Paramesotriton*.

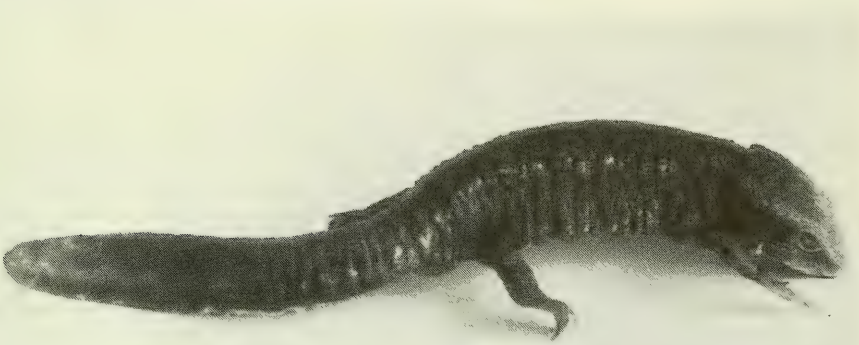

FIG. 1. Holotype of *Paramesotriton fuzhongensis*, GMC 81-021 from Gupo Hill, Wanggao (24° 35'N 111° 25'E), Guangxi Autonomous Region, China.

Paramesotriton fuzhongensis sp. nov.

Holotype: GMC 81-021 (Fig. 1), an adult male from Gupo Hill, Wanggao (24°35'N 111°25'E), Zhongshan Xian (county), Guangxi Autonomous Region, China, altitude 400 m. The specimen was collected on August 12, 1981 by Chaoliang Lai and is deposited in Guangxi Medical College collection (GMC).

Allotype: GMC 81-022 an adult male was collected with the holotype.

Paratype: Two males GMC 86-006 & 86-009 and three females GMC 86-004, 86-005, & 86-007 were sent by Fuchwan County Science and Technology Committee. The specimens were collected from Xilin Hill, Fuchwan Xian (county) [24°50'N 111°16'E], Guangxi Autonomous Region, China, altitude 500m. The exact date and collector are unknown.

Diagnosis: This new species closely resembles *Paramesotriton guangxiensis* Huang, Tang and Tang, but differs from the latter in the following ways: 1) When the fore limbs are drawn forward, their tips exceed the anterior margin of the eyes to a greater extent. 2) When the fore and hind limbs are drawn simultaneously along the flank toward the middle, the palm and

TABLE. 1. Measurements of the Holotype, Allotype, and Paratypes of *Paramesotriton fuzhongensis*. The mean given is only for the Paratypes

	Holotype Male GMC 81-021	Allotype Male 81-022	Paratype Male 86-006	Paratype Male 86-009	Paratype Female 86-004	Paratype Female 86-005	Paratype Female 86-007	mean	mm/SVL
Snout-vent length	88	75	82	81	80	69	73	77.0	-
Head length	27	24	23	23	34	21	21	22.3	0.29
Head width	20	17	16	17	16	15	14	15.4	0.20
Snout length	09	08	07	08	08	07	08	07.5	0.10
Internasal space	06	05	05	05	05	04	04	04.4	0.06
Diameter of eye	06	05	05	05	05	04	05	04.3	0.06
Interorbital space	08	07	07	07	07	07	07	06.9	0.09
Axilla-groin	39	32	35	34	37	33	34	34.6	0.45
Fore limb length	29	25	25	27	26	20	22	24.0	0.31
Hind limb length	30	25	27	28	27	22	23	25.4	0.33
Tail length	78	58	66	78	79	65	65	70.6	0.92
Tail-base width	10	07	09	09	10	08	09	08.9	0.12
Tail height	14	12	12	12	11	10	10	10.9	0.14

tarsus are overlapping. 3) The granular warts have a higher frequency and density. 4) The coloration differs between the two species.

Description of holotype: Total length 166 mm, snout-vent length (SVL) 88 mm; head depressed slightly, longer than broad; slightly ladder shaped in dorsal aspect, and hind region wider than fore; snout apparently longer than diameter of eye, with tip even and slightly bent, projecting far beyond anterior margin of lower jaw, with canthus rostalis prominent; loreal region slopes somewhat outward; top of head has two ridges behind eyes, reaching back of jugular plica and has nostrils lateral, on tip of snout that are not seen in dorsal view; oral gap exceeds posterior margins of eyes; upper labial fold is prominent and more developed under eyes; vormerine teeth V-shaped; tongue ovalform, lateral margins free, adhering to floor of mouth; lengths of fore and hind limbs nearly equal, with hindlimbs stouter and tip of fore-limb reaching midway between nostril and eye; adpressed limbs overlap along flank palm and tarsus; holotype has four fingers and five toes, very expanded and unwebbed, with blunt, round tips; first finger and toe very small; tail is shorter than SVL with thick base that gradually becomes laterally compressed, nearly a thin sheet at end; cloacal walls swollen and protuberant with many layers of papillae.

Skin very rough with prominent, protuberant dorsal ridge, anterior end separates and reaches posterior margin of the eyes; irregular costal grooves present on flanks and anterior part of tail; dense granules or warts cover dorsum of head, loreal region, throat, dorsum of body, flank, anterior part of tail and dorsal surfaces of limbs; large dorsolateral warts which form two longitudinal ridges; labial folds, belly, ventral surfaces of limbs, fingers, toes, palms, and tarsus smooth. Measurements of the new species are listed in Table 1.

In life, dorsum of head, back, lateral area of body and dorsal surface of limbs olive or have small black spots; anterior part of tail light brown, fading at end; sides have grayish-white stripes or various black spots; throat and belly light pale with irregular reddish orange spots that are smaller and more dense on throat; ventral caudal fin from tip of tail, to and including vent, and ventral surfaces of limbs reddish orange. In preservative color fades to whitish-gray.

Tail of female longer and lower than male; reddish orange spots on throat larger than male; vent of female shorter than that of male, not swollen, no papillae.

Habitat: The new species is restricted to streams at mid-slope where a broad leafed forest is present. Adults are usually found under rocks, and sometimes ashore. This

FIG. 2. Distribution of *Paramesotriton fuzhongensis* and *Paramesotriton guangxiensis* in Guangxi Autonomous Region China.

species is sympatric with *P. caudopunctatus* on Xilin Hill, Fuchuan Xian (County).

Distribution: *Paramesotriton guangxiensis* is known only from the type locality of 478 m, Paiyang mountain, Mingjiang (22°09'N 107°12'E), Ningming County, Nanning Prefecture, Guangxi Zhuang Autonomous Region, China. The new species *P. fuzhongensis* ranges from Fuchwan (24°50'N 111°16'E) south by southeast to Wanggao (24°35'N 111°25'E). Both localities are in Wuzhou Prefecture, Guangxi Zhuang Autonomous Region, China. Mingjiang, where *P. guangxiensis* occurs, is in the extreme southwestern portion of Guangxi Autonomous Region. In contrast, the two sites where the new species is found are in the northeastern part of Guangxi Autonomous Region. These two areas are separated by the Xi River system which drains most of Guangxi Zhuang Autonomous Region (Fig.2).

Comparisons: The new species differs from *P. guangxiensis* in a number of morphological traits besides those listed in the diagnosis. I have made additional comparisons as follows:

The head of the new species is longer and narrower (head width/head length = 69.5 %), and broader in *P. guangxiensis* (head width/head length = 78.2 %) [Fig. 3]. The tail of the new species is longer and

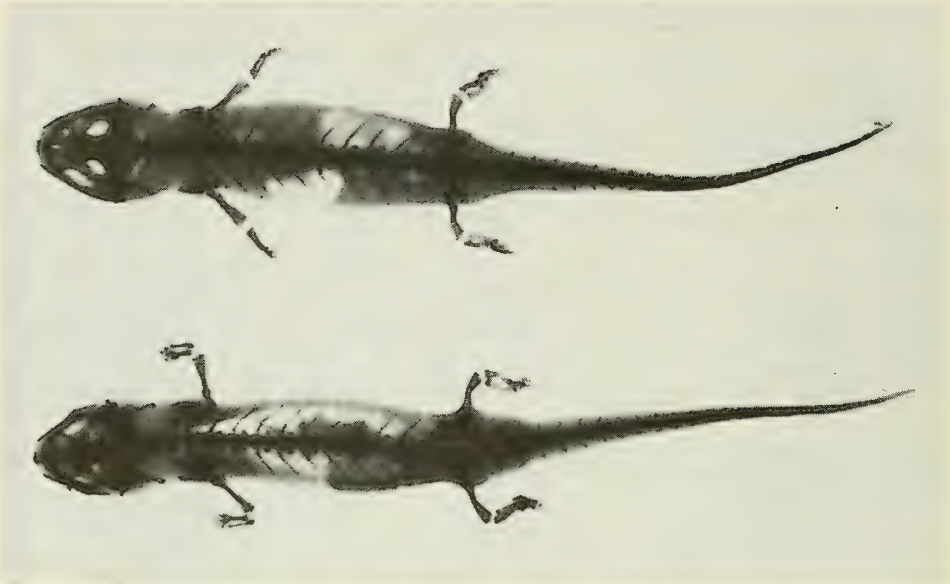

FIG. 3. X-Ray of *Paramesotriton fuzhongensis* (above) and *Paramesotriton guangxiensis* (below).

FIG. 4. Skulls of *Paramesotriton fuzhongensis* (left) with slender fronto-squamosal arch, and *Paramesotriton guangxiensis* (right).

lower (tail length/SVL = 91.7 %, tail height/SVL = 14.0 %), and is shorter and higher in *P. guangxiensis* (tail length/SVL = 82.5 %, tail height/svl = 19.3 %). The axilla to groin ratio is longer in the new species (axilla to groin/SVL = 44.9 %) than in *P. guangxiensis* (axilla to groin/SVL = 41.0 %). The data for *P. guangxiensis* are according to Huang, Tang and Tang (1983).

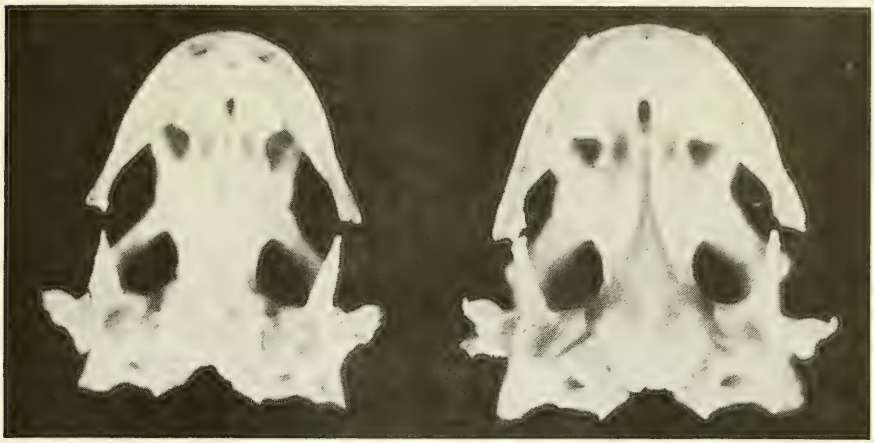

FIG. 5. Skulls of *Paramesotriton fuzhongensis* (left) with maxillary separated from the pterygoid, and *Paramesotriton guangxiensis* (right).

The fronto-squamosal arch of the new species is slender and the outer edge is almost a straight line. It is larger and stout, with the outer edge nearly a right angle, in *P. guangxiensis* (Figs. 3 & 4). The maxillary of the new species is separated from the pterygoid by a large interval, while it almost touches the anterior tip of the pterygoid in *P. guangxiensis* (Fig. 5). The notch of nares internus on the vomer in the new species is shallow and vertical. It is deeper and transverse in *P. guangxiensis* (Fig. 5). The trunk vertebrae of the new species are slender and the ribs direct more backward; the trunk vertebra are stout and the ribs direct more laterally in *P. guangxiensis* (Fig. 3). The seventeenth vertebra (third caudal vertebra) begins to have a hemal canal in the new species, instead of the sixteenth vertebra (second caudal vertebra) in *P. guangxiensis*. The hyoid apparatus in the two species differs in appearance, the ceratohyal being apparently shorter in the new species (Fig. 6).

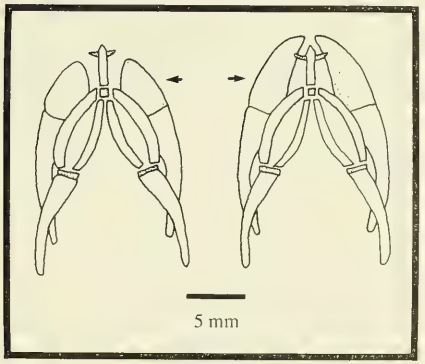

FIG. 6. Hyoid aparatus of *Paramesotriton fuzhongensis* (left), and *Paramesotriton guangxiensis* (right). Arrows show ceratohyal.

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[1] Currently, the name E. Djao is written E. Zhao (ed.).

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Defensive Behavior and Feeding Biology of the Asian Mock Viper, *Psammodynastes pulverulentus* (Colubridae), a Specialized Predator on Scincid Lizards

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Abstract. -Mock vipers react to simulated predation by immobility, locomotor escape, striking, and biting; they resemble some sympatric, venomous pit vipers in color pattern, enlarged front teeth, and head shape. One hundred and thirteen prey items included lizards, primarily scincids (70.8%); frogs (23.0%); and colubrid snakes (6.1%). There is no evidence of ontogenetic dietary variation and slight evidence of geographic dietary variation. Prey is subdued with venom and constriction, then swallowed head-first. Skinks are difficult for some predators to grasp, because teeth and talons slide on their hard, shiny scales and because their trunk musculature permits vigorous axial bending. Enlarged anterior maxillary and dentary teeth in *Psammodynastes pulverulentus* and several other genera of snakes evidently concentrate forces, function as pawls on a ratchet, and prevent scincid lizards from rolling off the tooth rows. Enlarged anterior teeth and a diet of skinks perhaps have evolved several times in colubrid snakes, but phylogenetic information is not available to resolve historical patterns of adaptation, exaptation, and convergence for multiple biological roles. The evolutionary success of scincids might result in part from decreased vulnerability to unspecialized lizard predators.

Key words: Snakes, *Psammodynastes*, Defense, Diet, Dentition, Adaptation.

Introduction

Much of the morphological diversification of snakes probably is related to defense against predators and to feeding, especially within the Caenophidia (or Colubroidea, "advanced snakes"; e.g., Gans 1961, Savitzky 1980, 1983, Ananjeva and Orlov 1982, Cundall and Greene 1982, Greene 1983, 1988a, Cundall 1987). Nevertheless, despite longstanding interest in that topic, few of the more than 2000 species have been subjected to detailed studies. The need for additional information is most acute for the Colubridae (*sensu lato*), because that largest of snake families is especially diverse in terms of cephalic morphology, defense, and diet (e.g., Malnate 1960, Savitzky 1983, Greene 1988a).

This paper summarizes the antipredator behavior and feeding biology of *Psammodynastes pulverulentus*, a small, rear-fanged, tropical forest snake that occurs at low to moderate elevations over much of southeastern Asia and the Indo-Australian archipelagos (Wall 1910a, Smith 1943, Rasmussen 1975, Leviton 1983). A case study of this species is of interest for three reasons, the first two of which are addressed in the Discussion section:

(i) *Psammodynastes pulverulentus* has an unusual and narrow diet that is functionally correlated with grooved, posterior fangs and enlarged anterior teeth. Its response to predators includes biting and overall resemblance to a venomous pit viper, such that the derived dentition might fill multiple biological roles. Understanding the relationships among morphology and behavioral ecology in mock vipers will be relevant to future, synthetic considerations of snake evolution, especially if the fangs of highly venomous proteroglyphous snakes (Elapidae) are indeed derived from enlarged anterior teeth (e.g., Hoffstetter 1939, Smith 1952, Rasmussen 1985, McDowell 1986).

(ii) Unlike many other lizards, scincids are relatively safe from generalized predators. Nevertheless, mock vipers eat mainly skinks, suggesting that both might have been involved in a coevolutionary "predator-prey race". With additional information on population biology and phylogenetic relationships, these taxa might prove useful in elucidating circumstances

under which that phenomenon can occur (see Mitter and Brooks 1983, Abrams 1986, Greene 1988a).

(iii) *Psammodynastes pulverulentus* is a widespread and sometimes common snake, judging from museum collections and comments in the literature (e.g., Wall 1910a, Rasmussen 1975), so it might play an important role in local ecosystems as predator and prey of other vertebrates (cf. Inger and Colwell 1977, Brown and Alcala 1986, Greene 1988b).

Methods

I examined all specimens of *Psammodynastes pulverulentus* in the American Museum of Natural History (AMNH); California Academy of Sciences; Field Museum of Natural History; Museum of Vertebrate Zoology, University of California, Berkeley (MVZ); National Museum of Natural History; and Rijksmuseum van Naturlijke Historie (RMNH). Only stomach contents were examined, thereby avoiding bias from differential digestability of prey (see Savitzky 1981). Direction of ingestion (inferred from orientation in the gut), identification, and linear dimensions of prey were recorded whenever possible. Intact prey (or a reference specimen of comparable size) and the predator snakes were weighed after blotting and draining them briefly on paper towels. Abbreviations refer to snout-vent length (SVL) and prey/predator mass ratio (MR). My results also incorporate literature records (Wall 1908, 1909, 1910a, 1910b, 1910c, 1926, Pope 1929, Mertens 1930, Smedley 1931, Brongersma 1934, Taylor and Elbel 1958, Saint Girons 1972, Auffenberg 1980, Leviton 1983), and I took care to account for redundancy among them and museum specimens (e.g., Brongersma 1934 and RMNH 6221). Behavioral observations were made on an adult male (SVL 325 mm, 16 g, now MVZ 172412) from an unknown locality.

Results

Morphology and Systematics

Psammodynastes pulverulentus is a small snake (maximum SVL of females ca. 630 mm, Wall 1910a). There is sexual dichromatism, but the dorsal color is always some shade of brown or gray. In general, snakes from the mainland and Java have lower ventral and caudal scale counts and shorter tails than do those from islands, differences that are perhaps correlated with increased arboreality in the latter (Rasmussen 1975).

Beginning anteriorly, the first 2-3 maxillary teeth of *Psammodynastes pulverulentus* are small, followed by one or two markedly enlarged teeth, a diastema, 4-12 small teeth, and two enlarged, grooved fangs; the large anterior and posterior teeth are approximately twice as long as the intervening small teeth. Secretions of the well-developed Duvernoy's glands presumably are conducted by the grooved posterior maxillary fangs. There is geographic variation in the number of small maxillary teeth, with a mode of eight or nine on the Philippine Islands, Sulawesi, Flores, Komodo, and Enggano, and a mode of five to seven elsewhere in the range. The anterior dentary teeth are enlarged and followed by smaller, widely spaced teeth (based on West 1895, Wall 1910a, Taub 1967, Gabe and Saint Girons 1971, Rasmussen 1975, and AMNH 27782; see Figs. 1, 2).

The only other species in the genus, *Psammodynastes pictus*, has dentition similar to that of the high tooth count populations of *P. pulverulentus*. Grossly similar dentition, with abruptly enlarged anterior or middle maxillary and dentary teeth are found in Old World colubrids of the genera *Ahaetulla*, *Cyclocorus*, *Lepturophis*, *Lycodon*, *Lycophidion*, *Macroprotodon Mehelya*, and *Psammophis*

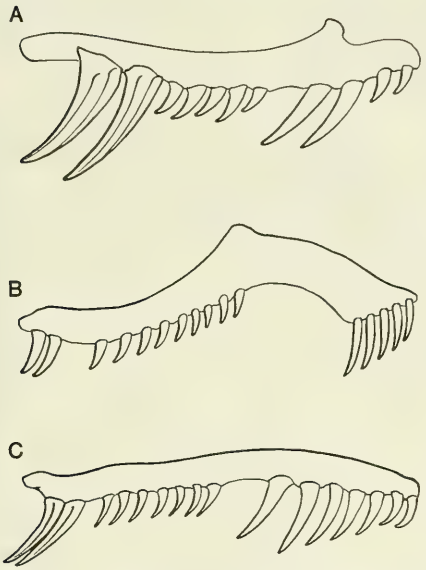

FIG. 1. Maxillae and dentition of (A) *Psammodynastes pulverulentus*, (B) *Lycodon aulicus*, and (C) *Ahaetulla nasuta* (adapted from Smith 1943). Anterior to right; not to scale.

(Boulenger 1893, West 1895, Smith 1943, Grandison 1972, Marx and Rabb 1972, Broadley 1983, Savitzky 1981), and in the Round Island bolyeriids *Bolyeria* and *Casarea* (Cundall and Irish 1989). However, in some *Ahaetulla* the anterior teeth are grooved (Hoffstetter 1939, Underwood 1967), in *Lycophidion* and *Mehelya* the duct of Duvernoy's gland opens near the enlarged anterior teeth (Savitkzy 1981), and in bolyeriids the disparity in tooth length is functionally enhanced by an intramaxillary joint (Cundall and Irish 1989). In *Ditypophis vivax* of Sokotra, the maxillary teeth increase in length from anterior to posterior, followed by a diastema, a single small tooth, and two enlarged grooved fangs (Parker 1949). *Pythonodipsas carinatus*, of southern Africa, is a rear-fanged colubrid with enlarged anterior palatine and dentary teeth that might be functionally equivalent to those described above (Marx et al. 1982).

The relationships among Old World colubrid genera exhibiting the heterogeneous dentition described above have not been resolved. Smith (1943) grouped *Psammodynastes* and *Psammophis*, but noted that the former seemed distant from all other colubrids. Parker (1949:90) viewed the maxillae of *Ditypophis* and *Psammodynastes* as "very similar," and thought those genera as well as *Pythonodipsas* are closely related. Underwood (1967) placed *Ahaetulla* and *Psammophis* in the Colubridae; *Cyclocorus, Lycodon, Lycophidion*, and *Mehelya* in the Lycodontinae of the Dipsadidae; and *Ditypophis, Macroprotodon*, and *Psammodynastes* in the Boiginae of the Homalopsidae. Recent biochemical approaches to snake systematics have not included those genera (Dowling et al. 1983, Dessauer et al. 1987, Cadle 1988). Irregardless of relationships among *Psammodynastes* and other colubrids exhibiting enlarged anterior or middle maxillary teeth, it is clear that condition is uncommon and derived relative to other advanced snakes (Marx and Rabb 1972). Lacking outgroup comparisons, Rasmussen's (1975) conclusion that a high number of small maxillary teeth is primitive for *Psammodynastes* seems premature.

Defensive Behavior and Mimicry

Many snakes are eaten by a variety of other reptiles, birds, and mammals (Greene 1988a); the only definite record of predation on *Psammodynastes pulverulentus* is RMNH 6221, from Sulawesi, found in the stomach of a colubrid snake (*Boiga dendrophila*, Brongersma 1934). Mock vipers exhibit a hierarchy of defensive reactions in response to simulated predation by humans, beginning with immobility and then vigorous attempts at locomotor escape ("even indulging in a series of leaps," Wall 1910a:75). When cornered or restrained, they typically assume a striking coil, with head erect and forebody retracted into sigmoid curves, and bite readily (Wall 1910a, Wall 1910c, Schmidt 1927, Pope

FIG. 2. Lateral view of live *Psammodynastes pulverulentus* holding a prey lizard (*Anolis carolinensis*). Note buccal tissue surrounding the enlarged anterior maxillary and dentary teeth of the snake.

1929, Mertens 1930, Frith 1977, pers. obs.). Smith (1915:174) saw one that "...was shy and very active, but made no attempt to bite when handled." The tissue-covered, enlarged anterior teeth are readily visible when the snake's mouth is opened (Schmidt 1927, Pope 1929, cf. Fig. 3), and the effect is reminiscent of the open-mouthed threat of some pit vipers. I noted no effects, other than brief bleeding, from a bite on the finger by MVZ 172412.

According to Wall (1910a:73), the similarity between *Psammodynastes pulverulentus* and a Himalayan pit viper, *Agkistrodon himalayanus*, "...is especially striking...and I know of no more remarkable resemblance between any two snakes of different families...The short and rather stout body, contracted tail, flattened head [there is a distinct canthus rostralis], swollen lips, large eye with vertical pupil, lustreless dorsal scales, and highly polished ventral plates are all very characteristic viperine traits, but the resemblances do not stop here, for its attitude of menace is very like that of vipers, added to which it is viviparous in habit."

The resemblance of *Psammodynastes pulverulentus* to dangerously venomous snakes (also noted by Soderberg 1967 and Saint Girons 1972) is subjectively impressive and merits further study (see Pough 1988). However, the mimicry hypothesis is complicated by the fact that the color pattern is cryptic in the snake's natural habitat (Wall 1910a), that the resemblance to sympatric pit vipers is probably less precise in many parts of its range than described by Wall (1910a; cf. Smith 1943, Lim 1979), and that the defensive posture is widespread among other colubrid snakes and thus need not be explained by mimicry (Kroon 1975, Greene 1988a, Pough 1988).

Diet

One hundred and nine *Psammodynastes pulverulentus* from throughout the species' range contained 113 prey items (x=1.03/snake): 65 scincid lizards (57.5%; including 1 "young" *Eumeces quadrilineatus*, 1 *Lygosoma* sp., 3 *Sphenomorphus florensis*, 2 *S. indicus*, 1 *S. schlegeli*; most of the rest appeared to be lygosomines), 1 limbless anguid lizard (0.9%; *Ophisaurus gracilis*), 2 lacertid lizards (1.8%; 1 *Tachydromus* sp., 1 *T. sauteri*), 5 gekkonid lizards (4.5%, 1 *Cyrtodactylus darmandvillei*, 1 *Hemidactylus* sp.), 7 agamid lizards (6.3%; including 1 *Calotes jerdoni*, 1 *C. mystaceus*, 1 *Ptyctolaemus gularis*), 26 frogs (23.2%; including 1 *Oreophryne jeffersoniana*, Microhylidae; 1 *Rana limnocharis*, 1 *R. microdisca*, Ranidae), and 7 colubrid snakes (6.3%; including 3 cf. *Calamaria* sp.). The frogs, *Calamaria*, *O. gracilis*, and lygosomine skinks are mainly terrestrial, whereas the geckos, agamids, and *T. sauteri* are at least partly arboreal (e.g., Schmidt 1927, Pope 1929, Smith 1935, Inger 1954, Auffenberg 1980, Lue et al. 1987). If the anguid and snakes are combined with skinks, elongate vertebrates with shiny scales constitute ca. 65% of the prey.

Most mock vipers had empty stomachs or contained a single item; stomachs with multiple items contained three skinks (once) and a skink and a colubrid snake (twice). There is no evidence of ontogenetic variation in diet: eight juveniles (SVLs 140-198 mm, cf. Wall 1910a) had eaten six skinks, one agamid (*Calotes mystaceus*), and one frog. Given small sample sizes, the data provide only a hint of significant geographic dietary variation. The incidences of lizards, frogs. and snakes, respectively, are as follows: 52, 15, and 5 versus 26, 11, and 2 for the grouped low versus high tooth count populations (Rasmussen 1975, see above); 14, 2, and 4 versus 38, 13, and 1 for Java versus grouped other low tooth count populations; 45, 9, and 4 versus 33, 17, and 3 for short-tailed versus long-tailed populations (Rasmussen 1975, see above); and 31, 7, and 0 versus 47, 19, and 7 for grouped mainland versus island populations. If lizards and snakes are lumped (to provide minimum expected values for chi square analysis), the only significant difference in predation on reptiles versus frogs is for short-tailed vs. long-tailed groups ($p<.05$). These findings and those of Rasmussen (1975) suggest that snakes on the mainland and Java might have shorter tails, have fewer pre-diastemal small teeth, and consume relatively more reptiles than frogs compared to those from other islands. All records of predation on snakes are from islands.

MR values (0.06-0.26, x=0.13, N=12) are not especially large relative to other snakes (cf. Voris and Moffett 1981, Greene 1983, 1984, Seib 1984, 1985, Jayne et al. 1988). Mean MRs for seven prey lizards (0.13), three prey snakes (0.14), and two prey frogs (0.14) are so similar to the overall mean that simple frequencies accurately represent the importance of each prey type in the diet (see Greene 1986, Losos and Greene 1988).

Feeding Behavior

Individual and geographic variability remain to be assessed, but the feeding behavior of my captive mock viper was consistent during at least 12 complete sequences. Prey was always approached to within ca. 5 cm and seized with a rapid strike to the torso, neck, or snout. Constricting coils were applied by winding anterior loops without a twist, an action pattern common to many other colubrids (Willard 1977, Greene and Burghardt 1978; Fig. 3). Skinks were typically pinned behind the enlarged, anterior maxillary and dentary teeth during constriction, and even large prey (maximum MR=0.31) never escaped despite vigorous struggles (Fig. 3). Venom clearly affected small iguanid and

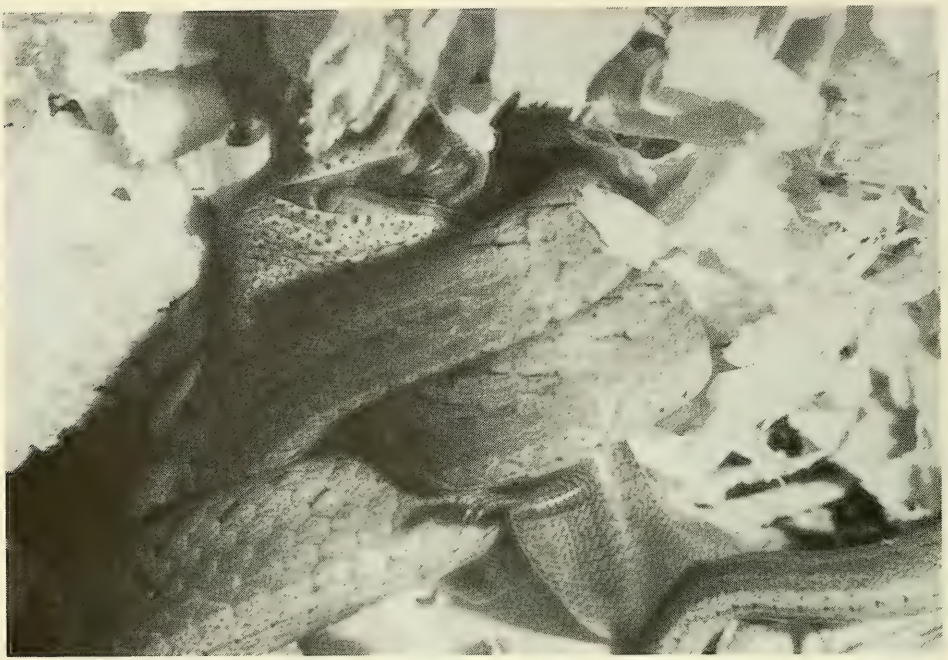

FIG. 3. Mock viper, *Psammodynastes pulverulentus*, constricting and envenomating a scincid lizard, *Eumeces tetragrammus*. Note enlarged anterior maxillary and dentary teeth restraining the skink, and posterior maxillary fang penetrating the prey's nostril.

scincid lizards, as they were limp and immobile during ingestion (Shaw [cited in Smith 1943] and Gabe and Saint Girons [1971] noted rapid mortality of lizards and a snake bitten by this species).

Prey were always manipulated in the jaws without release, then usually swallowed head-first by the captive mock viper, as is typical of many snakes (Greene 1976, 1983, 1984, Ananjeva and Orlov 1982, Voris and Voris 1983, Seib 1984, 1985). Among 74 natural prey items for which direction of ingestion was determined, 46 lizards, 12 frogs, and seven snakes were swallowed head-first; three lizards and two frogs were swallowed bent-double; and three lizards and one frog were swallowed tail-first ($p < .01$, chi square test, for head-first versus not head-first). Times from seizing 4 and 5 g prey lizards (*Eumeces* sp.) until completion of ingestion were 24.7 and 29.8 minutes, respectively, for the captive snake.

Information on Other Taxa

Species of *Ahaetulla* (Smith 1943, Lim 1956, Leviton 1968, Henderson and Binder 1980, pers. obs.), *Cyclocorus* (Taylor 1922, Leviton 1965a), *Lepturophis* (Lim and Kamarudin 1975), *Lycodon* (Smith 1943, Leviton 1965b, pers. obs.), *Lycophidion* (Branch 1976, Savitzky 1981, Broadley 1983), *Macroprotodon* (Ferrand de Almeida and Ferrand de Almeida 1986), *Mehelya* (Savitzky 1981, Broadley 1983), and *Psammophis* (Smith 1943, Broadley 1983) feed frequently on lizards, especially, at least in some cases, on skinks. Relatively large skinks are trapped behind and/or impaled on the enlarged anterior teeth of *Lycophidion* (Broadley 1983, Savitzky pers. comm.), but I am not aware of observations on feeding in the other genera with respect to use of the

anterior teeth. Nothing is known about the diet of *Ditypophis vivax*. *Pythonodipsas carinatus* eats skinks and geckos (Marx et al. 1982). A bolyeriid, *Casarea dussumieri*, eats skinks and geckos in nature, and its enlarged anterior teeth and divided maxillae might function analogously to those of *Psammodynastes pulverulentus* during feeding (Cundall and Irish 1989).

Skinks are occasionally taken by a variety of reptiles, birds, and mammals throughout the world (e.g., Taylor 1952, Fitch 1954, Greene 1988a, Losos and Greene 1988), but observations on captive predators indicate that they might often have trouble handling these lizards. Vitt et al. (1977:329) noted that "Smooth scales and rolling movements allowed some skinks [*Eumeces* sp.] to escape by breaking the grip...[of snakes, *Lampropeltis* sp. and *Diadophis punctatus*, both of which lack enlarged anterior teeth]". A rear-fanged snake, *D. punctatus*, lost two of five small skinks (*Eumeces* sp., MRs ca. 0.10) when they rolled out of its grip (pers. obs.). In captivity a skink escaped from the grasp of a *Casarea dussumieri*, "owing to the glossy nature of its scales" (Vinson 1975:64). A pigmy owl, *Glaucidium minutissimum*, readily ate *Anolis* lizards, but each of four times "only a slight wiggle caused...[a skink's] extremely smooth body to squirt out of her talons" (Janzen and Pond 1976:73). Some gekkonid lizards might pose similar problems for predators, due to their fragile, easily torn skin (Greene 1988a, Bauer et al. 1988, Branch 1988:Pl. 84).

Discussion

Psammodynastes pulverulentus resembles many other small, venomous, constricting snakes in some aspects of defensive behavior and feeding biology (e.g., sigmoid threat posture and biting, prey size, head-first ingestion), but is highly unusual in terms of dental morphology, diet, and perhaps resemblance to sympatric pit vipers. Three concepts that describe historical patterns among phenotypic attributes, performance advantage, and ecology are relevant here: A feature is an adaptation for a particular task if its evolutionary origin was associated with a performance advantage at that task. A feature is an exaptation if its origin preceded an association with that performance advantage. Convergence is independently derived similarity, and might reflect adaptive, exaptive, or non-functional resemblance. Untangling these relationships requires information on phylogenetic relationships, natural history, and performance capabilities (for further discussion and references, see Gould and Vrba 1982, Greene 1986, Schaefer and Lauder 1986).

Three lines of evidence suggest that markedly enlarged anterior maxillary and dentary teeth in *Psammodynastes pulverulentus* and certain other snakes are functionally correlated with increased effectiveness at capturing skinks:

(i) Insofar as known, most snakes with that dentition emphasize skinks in the diet. Examples include several genera of colubrids and possibly two genera of bolyeriids; the only clear exceptions are two genera of arboreal boids, *Chondropython* and *Corallus*, that prey mainly on mammals (McDowell 1975, Groves and Greene, unpubl.), and the former does eat skinks.

(ii) Direct observations of *Lycophidion* sp. and *Psammodynastes pulverulentus* (see above) suggest that the enlarged anterior teeth function like pawls on a ratchet, *viz.*, by trapping slippery, writhing prey in the mouth. A single observation of *Casarea dussumieri* (Vinson 1975) is contradictory.

(iii) Preliminary observations on a captive mock viper and on other predators lacking the specialized dentition indicate a difference in handling ability consistent with that hypothesis. Those observations also support the hypothesis that skinks escape from generalized predators by virtue of their powerful trunk musculature and shiny, impenetrable scales.

The evidence is consistent with an

adaptive relationship between enlarged anterior teeth and a diet of skinks in certain colubrids, as is the order of their respective origins in the Mesozoic (Estes 1983) and Cenozoic (Cadle 1987). However, the functional relationship might be exaptive, as implied by the fact that some species with enlarged anterior teeth might feed frequently on frogs and/or non-scincid lizards (e.g., some *Ahaetulla*, *Cyclocorus*, *Lepturophis*, *Psammodynastes*, and *Psammophis*, such that a diet of skinks might not be primitive), and by the possibility of a defensive role for the enlarged teeth in *Psammodynastes pulverulentus*. Lacking information on the relationships of genera with enlarged anterior teeth to each other and to taxa lacking that attribute, we cannot distinguish between homologous and convergent similarity--adaptive or otherwise--in morphology and ecology among the colubrids. Surely the similar dentitions of bolyeriids and skink-eating colubrids are independently derived (Cundall and Irish 1989).

Thus far, most limbless or near-limbless squamates that eat mainly skinks fall into two groups. Pygopodid lizards, xenopeltid snakes, and several genera of colubrids have small hinged teeth that impinge on the trailing edges of skinks' scales (Savitzky 1981, 1983; Patchell and Shine 1986a, 1986b, 1986c); in at least one colubrid, *Scaphiodontophis*, ingestion is extremely rapid (Henderson 1984). Bolyeriids, *Psammodynastes pulverulentus*, and several other genera of colubrids use enlarged anterior teeth to restrain a struggling skink's body, and ingestion is not particularly rapid. African colubrids of the genera *Lycophidion* and *Mehelya* possess both tooth types on a single maxillary bone (Savitzky 1981). Whether those differences reflect chance, morphological constraints among different lineages, or ecological differences is an interesting and unanswered question.

Venom aids *Psammodynastes pulverulentus* and perhaps other snakes that eat skinks in subduing potentially difficult and even dangerous prey, but it also might be involved in the antipredator response of mock vipers. However, as yet neither of those roles can be applied to questions about the adaptive origin of rear fangs (e.g., Kardong 1979) because we lack phylogenetic information on the origin of venom injection in the history of mock vipers (cf. Cadle 1983).

Skinks are widespread, morphologically and ecologically diverse, and often abundant components of lizard faunas; more than 1000 extant species have been described worldwide (Greer, 1976). Observations on the diets and behavior of lizard predators (see above) suggest that the impressive evolutionary success of this family might reflect, in part, a decreased vulnerability to unspecialized predators. Although a variety of lizard-eating reptiles, birds, and mammals occasionally eat skinks (Greene 1988a), every species of snake and pygopodid lizard known to prey frequently on them in Africa and the Indo-Australian region exhibits morphological specializations for that diet (see above and Savitky 1981, 1983, Patchell and Shine 1986a, 1986b, 1986c, Cundall and Irish 1989). Putative antipredator mechanisms cannot entirely explain the success of skinks, because shiny, hard scales (underlain by osteoderms) and powerful trunk musculature probably facilitate a variety of limbless locomotor responses (Gans 1975), and because each of those traits is primitive for a higher taxon within which other families have sustained only modest radiations (Estes 1983, Estes et al. 1988).

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The Karyotype of the Treefrog *Rhacophorus reinwardtii* (Boie) from Xishuangbanna Daizu Autonomous Prefecture, Yunnan Province, China

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Abstract. -The Chinese Flying Treefrog, *Rhacophorus reinwardtii*, has a diploid chromosome number of 26, with 5 pairs of large and 8 pairs of small chromosomes. A secondary constriction occurs in the paracentric region of the short arm of the first chromosome pair. Submetacentric chromosomes occur on large pairs 2, 3, and 4. No other rhacophorid frogs are known to have these karyotypic features. The significance of these findings for chromosomal evolution in rhacophorid frogs is considered.

Key words: Anura, Rhacophoridae, *Rhacophorus*, Cytotaxonomy, Yunnan, China.

Introduction

Chinese rhacophorid frogs are numerous (about 40 species) and their taxonomic position, especially their supraspecific classification, is controversial (Liu and Hu 1961, Liem 1970, Jiang et al. 1987). In recent years we have been attempting to use cytotaxonomical methods and data to clarify the situation.

Karyotypes have been reported for only a few of the many species of Chinese rhacophorid frogs. Gao et al. (1985) reported the karyotype and its C-banding of *Rhacophorus dennysi*. Yang and Wu (1986) reported the karyotype of a new tree frog, *Rhacophorus gongshanensis*. Tan et al. 1987a, reported the karyotype, C-banding and Ag-NORs of *Rhacophorus chenfui*. Tan (1987) reported an extraordinary condition in which different diploid numbers (2n=26 and 2n=16) were found in single individuals of the small treefrog, *Philautus doriae*. This paper reports the karyotype of *Rhacophorus reinwardtii*.

Methods

In a survey of the herpetofauna of Xishuangbanna Daizu Autonomous Prefecture, Yunnan Province, China, during May and June, 1986, over 50 specimens of the Chinese Flying Treefrog, *Rhacophorus reinwardtii*, were collected in the vicinity of Mengleng, at Buyuan River, 19 km WNW of Mengxing (21° 55' N 101° 22' E). Fifteen of these specimens were used to examine its karyotype. The reproductive habits of this treefrog were observed and described in another paper (Tan et al. 1987b).

Mitotic chromosomes were prepared from bone marrow tissues using a modified direct chromosome-making method. An injection of 0.2 ml of a 0.1% solution of colchicine was injected intraperitoneally, and after 10 hours the specimens were sacrificed. The long bones were dissected from the four limbs. The two ends of the bones were removed and the bone marrow cells were washed directly onto the slides and fixed by using a vapor of ethanol, acetic acid, and distilled water in a ratio of 1:2:3. After being fixed for 2 hours, the slides were stained in a 2% Giemsa solution (pH 6.8-7.0), and photographed using a camera fixed on a Nikon microscope. For detailed information, refer to Tan et al.(1987a). Terminology was adopted from Levan et al. (1964).

Results

More than 50 metaphase chromosome spreads were observed and counted. *Rhacophorus reinwardtii* has a diploid chromosome number of 26. The karyotype

TABLE. 1. Proportional data from 10 well spread metaphase chromosomes.

Chromosome no.	Relative Length	Arm Ratio	Centromeric Type
1	14.83 ± 0.63	1.30 ± 0.15	metacentric
2	12.14 ± 0.50	1.89 ± 0.22	submetacentric
3	11.14 ± 0.55	1.83 ± 0.22	submetacentric
4	10.69 ± 0.44	1.73 ± 0.19	submetacentric
5	09.61 ± 0.24	1.26 ± 0.07	metacentric
6	06.32 ± 0.28	1.39 ± 0.15	metacentric
7	05.89 ± 0.24	1.40 ± 0.17	metacentric
8	05.78 ± 0.20	1.27 ± 0.09	metacentric
9	05.40 ± 0.23	1.44 ± 0.21	metacentric
10	04.96 ± 0.31	1.23 ± 0.17	metacentric
11	04.61 ± 0.28	1.19 ± 0.13	metacentric
12	04.28 ± 0.30	1.15 ± 0.10	metacentric
13	04.02 ± 0.35	1.26 ± 0.15	metacentric

of *Rhacophorus reinwardtii* consists of 5 pairs of large (relative length larger than 9%) and 8 pairs of small (relative length smaller than 7%) chromosomes (Table 1).

Discussion

Rhacophorus reinwardtii has a karyotype of 2n=26 with 5 large and 8 small pairs of chromosomes. This is often seen in the Rhacophoridae and may be either a primitive retention, or a synapomorphy. Many ranid frogs which are thought to be sister groups of the family Rhacophoridae (Inger 1967, Duellman 1988) have a similar karyotype.

As we have pointed out previously, the arm ratios of the chromosomes are useful in differentiating closely related species (Zhao et al. 1987). Moreover, Morescalchi (1973) proposed that there may be a relationship between how primitive the chromosomes are and the chromosomal arm ratios: the more primitive species tend to have more chromosomes with submetacentric, subtelocentric and telocentric centromeres. This hypothesis has been corroborated in most of the groups we have studied (Tan et al 1987a). This rather specialized and advanced

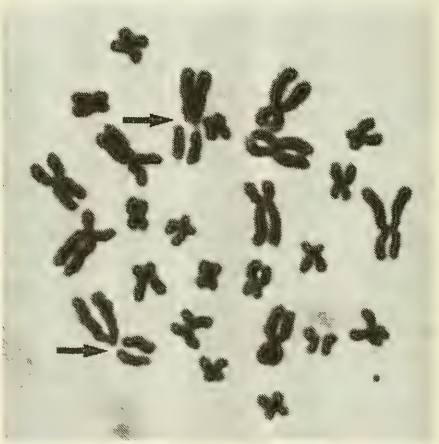

FIG. 1. Metaphase chromosomes of *Rhacophorus reinwardtii*. Arrows indicate the secondary constrictions.

treefrog (Jiang et al. 1987) with only 3 pairs of submetacentric chromosomes, supports this hypothesis. Exceptions to this generalization also have been observed in some groups (refer to Zhao et al. 1987). Attention should be paid to different members of closely related groups when

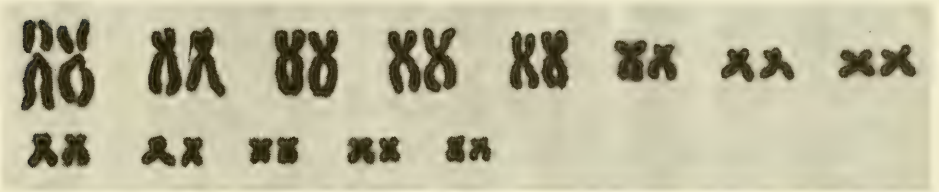

FIG. 2. Karyotype of metaphase chromosomes from figure 1.

studying chromosomal evolution and phylogeny.

The position of the secondary constriction on the chromosomes is another important criterion in cytotaxonomy. As shown in figures 1 and 2, *Rhacophorus reinwardtii* has a prominent secondary constriction in the paracentric regions of the short arms of the largest no. 1 chromosome. This is presumed to be the Nuclear Organizing Regions (NORs). In contrast, *Rhacophorus chenfui* (=*Polypedates chenfui*) has a prominent satellite on the terminal of the long arm of no. 11 chromosome, which has been shown to be the NORs.

To date several authors have reported on the classification of the Rhacophoridae which has a distribution limited to the Old World. Liem's family revision (1970) divided it into 14 genera in the Orient, Madagascar and the African tropics. Frost (1985) recoginized 2 subfamilies (Philautinae and Rhacophorinae) and 10 genera. Jiang et al. (1987) studied 14 species of Chinese Rhacophoridae and identified 5 genera (*Buergeria, Philautus, Polypedates, Rhacophorus* and *Chirixalus*) instead of the 2 previously recognized genera (*Rhacophorus* and *Philautus*). The karyotypes of *Polypedates dennysi* (=*Rhacophorus dennysi*), *P. leucomystax* (=*Rhacophorus leucomystax*), *P. chenfui* (=*Rhacophorus chenfui*), *Chirixalus doriae* (=*Philautus doriae*) and *Rhacophorus reinwardtii* have been reported. Further studies should be carried out in order to give convincing evidence for the taxonomical position and phylogeny of the Chinese rhacophorid frogs.

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Cytotaxonomical Studies on Chinese Pelobatids V. The Karyotypes, C-bands and Ag-NORs of *Megophrys omeimontis* and *Oreolalax schmidti*

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Abstract. -Chromosome preparations were successfully stained for C-bands and Ag-NORs in two Chinese pelobatids, *Megophrys omeimontis* and *Oreolalax schmidti*. It is thought that karyotypes of Chinese pelobatids have two formulae: 5+6 and 6+7. Most of them have the secondary constriction on 6q always associated with the C-band, and in these two species, associated with the NORs.

Key words: Anura, Pelobatidae, *Megophrys*, *Oreolalax*, Cytotaxonomy, Sichuan, China.

TABLE 1. The diploid chromosome numbers of *Megophrys omeimontis* and *Oreolalax schmidti*.

Species	Sex	No. of cells	2n=24	2n=25	2n=26	2n=27	2n=28
Megophrys omeimontis	Female	66	1	2	63	-	-
	Female	8	1	-	7	-	-
Oreolalax schmidti	Male	43	-	1	42	-	-
	Male	30	-	-	1	2	27
	Male	6	-	-	-	-	6

Introduction

The karyotypes of pelobatids have been reviewed by Morescalchi (1973). The karyotypes of 13 species of pelobatids in China have been investigated (four species of the genus *Vibrissaphora*, Zhao et al. 1983; *Scutiger boulengeri*, Wu 1984; *Brachytarsophrys carinensis*, Tan et al. 1987; *Vibrissaphora ailaonica*, Wu and Zhao 1987; *Megophrys lateralis* and *Atympanophrys shapingensis*, Wu 1987; and the four species of the genus *Oreolalax*, Wu et al. 1988). Until now the majority of comparative chromosomal investigations on pelobatids have been performed by conventional staining methods. Two instances of banding analyses on Chinese pelobatids were on *Atympanophrys shapingensis* (Wu 1987) and the four species of *Oreolalax* (Wu et al. 1988). In this paper both C-bands and Ag-NORs were used for analysis of the karyotypes. The results from C-banding and Ag-NORs banding in pelobatids will provide evidence for discussions on the evolution in the family Pelobatidae.

Methods

Two species of Pelobatidae, *Megophrys omeimontis* and *Oreolalax schmidti* were collected at Mt. Emei (29°32'N 103°21'E), Sichuan Province, China in May 1988. Both ends of the femur, tibiofibula, humerus, ilium, and coccygeum were cut off and marrow cells were washed out with 0.4M KCL for chromosome preparation by a centrifugal air-drying method (Wu et al. 1981). The samples were stained with 2% Giemsa (diluted by PBS, PH 6.8-7.0). C-banding was prepared following Sumner (1972). Ag-NORs banding was made by a developed Ag-NORs banding making

TABLE. 2. Proportional data of the karyotypes from *Megophrys omeimontis* and *Oreolalax schmidti*.

Chromosome no.	Relative Length	Arm Ratio	Centromere Position
	Megophrys omeimontis	*Megophrys omeimontis*	*Megophrys omeimontis*
1	18.24 ± 1.33	1.13 ± 0.16	metacentric
2	15.15 ± 0.89	1.73 ± 0.19	metacentric, submetacentric
3	13.40 ± 0.95	1.85 ± 0.18	submetacentric
4	11.22 ± 0.78	1.64 ± 0.34	metacentric
5	9.90 ± 0.62	1.57 ± 0.17	metacentric
6	6.97 ± 0.56	1.37 ± 0.18	metacentric
7	4.80 ± 0.80	2.42 ± 0.80	submetacentric
8	4.22 ± 0.38	1.50 ± 0.31	metacentric
9	4.02 ± 0.36	-	telocentric
10	3.49 ± 0.30	1.29 ± 0.26	metacentric
11	3.24 ± 0.28	1.16 ± 0.22	metacentric
12	2.81 ± 0.28	2.36 ± 1.01	submetacentric
13	2.53 ± 0.29	-	telocentric
	Oreolalax schmidti	*Oreolalax schmidti*	*Oreolalax schmidti*
1	17.52 ± 0.70	1.36 ± 0.10	metacentric
2	13.96 ± 0.86	1.63 ± 0.12	metacentric
3	12.56 ± 0.78	1.71 ± 0.10	submetacentric
4	11.84 ± 0.64	1.93 ± 0.20	metacentric
5	10.35 ± 0.39	1.51 ± 0.10	metacentric
6	6.24 ± 0.59	1.53 ± 0.30	metacentric
7	5.11 ± 0.47	1.50 ± 0.32	metacentric
8	4.77 ± 0.37	1.54 ± 0.11	metacentric
9	4.32 ± 0.41	1.60 ± 0.28	metacentric
10	3.95 ± 0.43	1.34 ± 0.33	metacentric
11	3.53 ± 0.43	1.27 ± 0.38	metacentric
12	3.04 ± 0.34	1.06 ± 0.14	metacentric
13	2.57 ± 0.30	-	telocentric

technique (Tan et al.1986).

Results

Chromosome numbers for the two species studied are shown in table 1. We found that the diploid chromosome number of *Megophrys omeimontis* was 26. However, two of the three specimens of *Oreolalax schmidti* were 28 and one was 26. Variation in the number of diploid chromosomes was also found in another species of pelobatid, *Brachytarsophrys carinensis* (Tan et al. 1987). We assume the standard diploid chromosome number of *O. schmidti* is 26. There was a pair of extra small chromosomes (Table 1).

The karyotypes in which the diploid chromosome numbers are 26 were measured for each species (Table 2). The

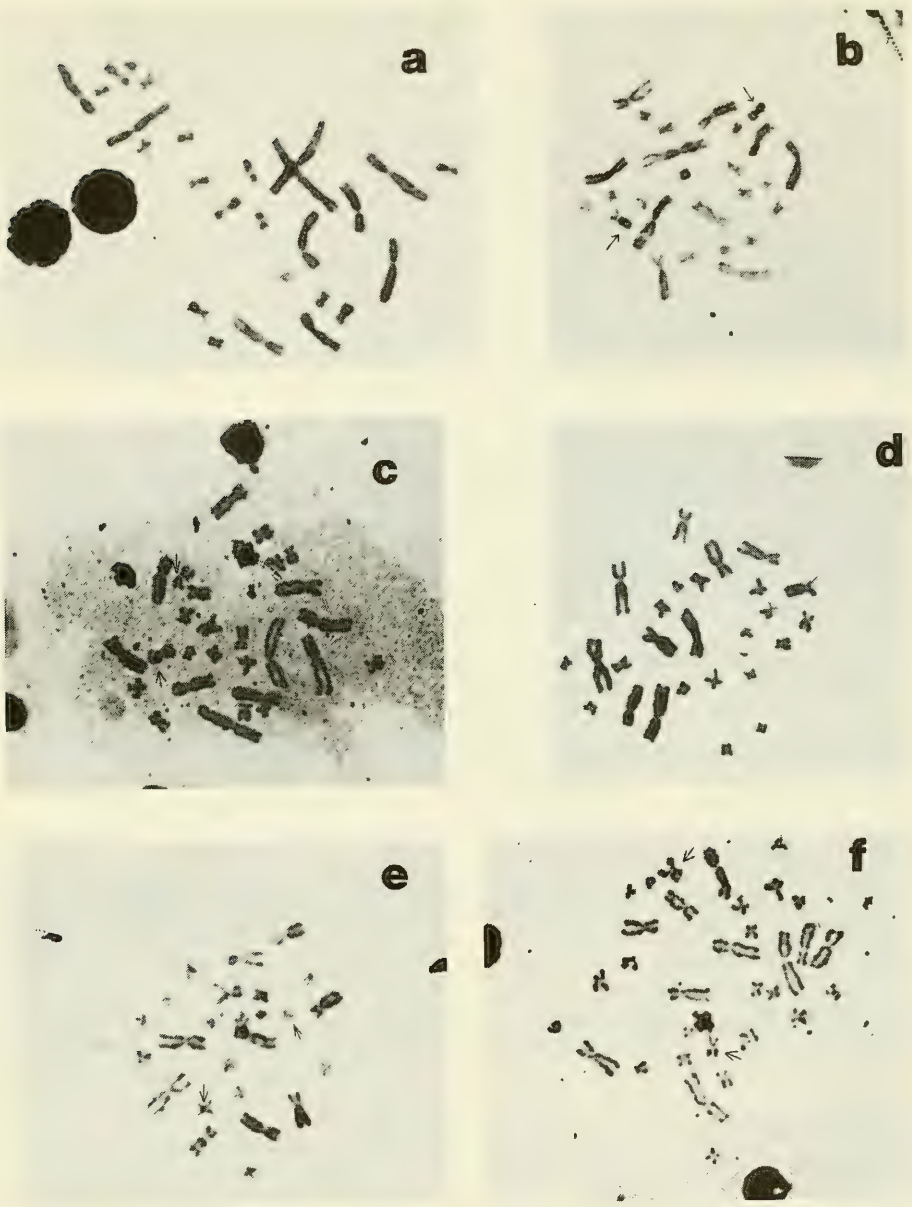

FIG. 1a. Spread of metaphase chromosomes from *Oreolalax schmidti*, a, b, and c showing c-bands and Ag-NORs 2n = 26; d, e, and f showing c-bands and Ag-NORs 2n = 28.

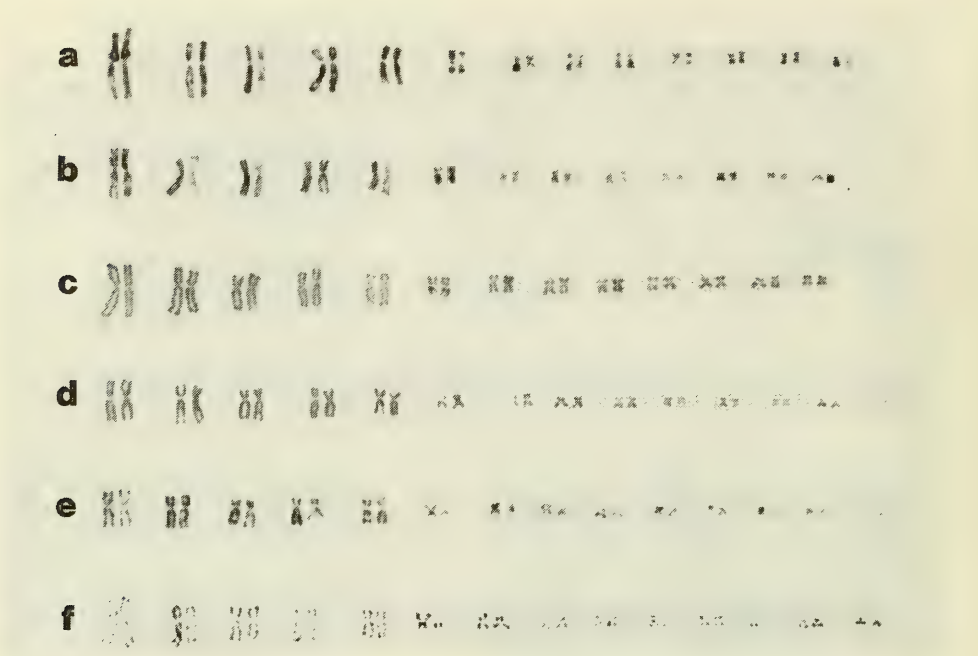

FIG. 1b. Karyotype of metaphase chromosomes from *Oreolalax schmidti*, a, b, and c showing c-bands and Ag-NORs 2n = 26; d, e, and f showing c-bands and Ag-NORs 2n = 28.

karyotype of *M. omeimontis* was 2n=26 with seven pairs of metacentric chromosomes (nos. 1, 4, 5, 6, 8, 10, and 11); three pairs of submetacentric chromosomes (nos. 3, 7, and 12); two pairs of telocentric chromosomes (nos. 9 and 13); the centromere type of the no. 2 chromosome was between metacentric and submetacentric.

The chromosomes of *O. schmidti* were metacentric except for no. 2 which was submetacentric and no. 13 which was telocentric.

The secondary constriction can be found in both species. It is in a pericentric position on the long arm of chromosome no. 6. This secondary constriction was not conspicuous in a few cells from both species. It is impossible to know whether sex chromosomes are present because only male *M. omeimontis* and female *O. schmidti* were looked at.

The results of C-banding and Ag-NOR banding are presented in table 3 and figures 1 and 2. In both *O. schmidti* and *M. omeimontis* there was a strongly C-band-positive associated with the Ag-NORs located in the position of the no. 6 chromosome long arm. In addition, the strongly C-band-positive was in a centric position on each pair of the *M. omeimontis* chromosomes. Neither the C-banding nor the Ag-NORs banding technique demonstrated heteromorphism between homologous heterochromatic regions in the two species.

On the chromosomes of *O. schmidti*, whose diploid chromosome number is 28, C-banding and Ag-NORs were successful, but these techniques did not reveal heterochromatic regions on the extra pair of

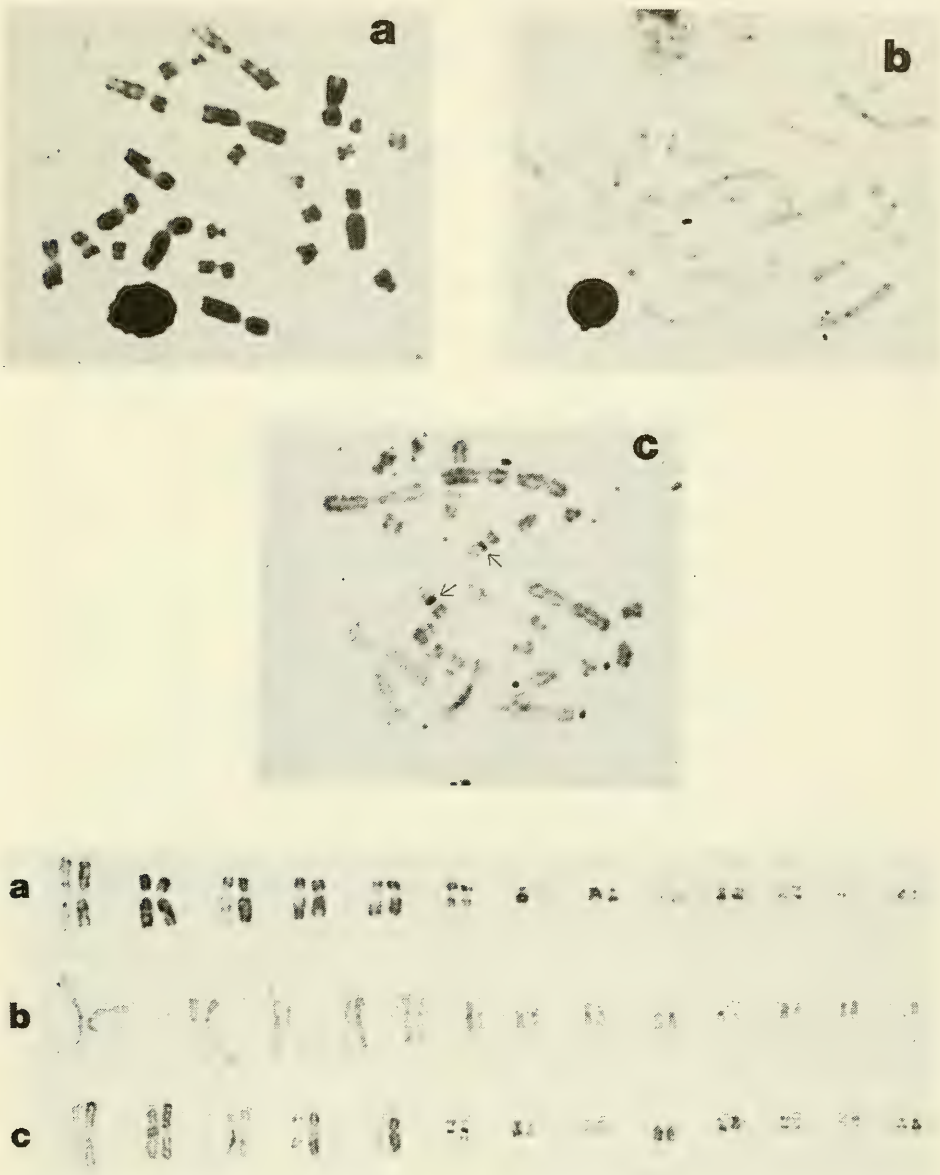

FIG. 2. Spread and karyotypes of metaphase chromosomes from *Megophrys omeimontis*, a, b, and c showing c-bands and Ag-NORs 2n = 26.

TABLE. 3. The karyotypes of Chinese pelobatid species that have been investigated.

Subfamily	Species	NF	Genome Type	SC
Megophrynae	*Atympanophrys shapingensis*	52	5 + 8	1q
	Brachytarsophrys carinensis	44	5 + 8	9q
	Megophrys lateralis	52	6 + 7	(5p)
	Megophrys omeimontis	48	5 + 8	6q
Oreolalaxinae	*Oreolalax omeimontis*	52	6 + 7	6q
	Oreolalax pingii	52	6 + 7	6q
	Oreolalax rugosa	52	6 + 7	6q
	Oreolalax schmidti	50	5 + 8	6q
	Scutiger boulengeri	52	6 + 7	(2p)
	Vibrissaphora ailaonica	52	6 + 7	6q
	Vibrissaphora boringii	52	6 + 7	6q
	Vibrissaphora leishanensis	52	6 + 7	6q, 7q
	Vibrissaphora liui	52	6 + 7	6q
	Vibrissaphora yaoshanensis	52	6 + 7	6q

chromosomes.

Discussion

1. The chromosomal polymorphism of *O. schmidtii*.

From the results, it is surprising that the diploid chromosomal number is 28 in two specimens and 26 in the third individual (Fig.1).

The former have an extra pair of smaller chromosomes. Moreover, heterochromatin was not shown on any segments of this extra small pair of chromosomes by C-banding and no NORs were discovered (Fig.1). A similar situation was found in *Brachytarsophrys carinensis* which were also obtained from the Heng Duan Mountains (Tan et at. 1987). They examined 12 specimens and found that the diploid chromosome number was 26 in eight individuals, 27 in three, and 28 in one. In 2n=27, the single extra chromosome was the same as the extra pair of chromosomes in 2n=28. As in *O. schmidti* no C-band-positive or NORs were found. Since B-chromosomes are consistently associated with heterochromatin (Schmid 1978b), they consider the extra 1-2 chromosomes not to be B-chromosomes, but a chromosomal polymorphism.

All except one species of Chinese pelobatid is distributed in the Heng Duan

TABLE. 4. C-banding and Ag-NORs position of Chinese pelobatid species that have been investigated.

Species	C-band hetero-morphism	Position of Ag-NORs
Megophrys lateralis	all 13 centric 1q, 2q, 7q (pericentric or proximal) 1 - 5q (terminal) 1p (interstitial)	1q (telomeric)
Megophrys omeimontis	all 13 centric 6q (interstitial)	6q (pericentric or proximal)
Oreolalax pingii	all 13 centric 1 - 5q (terminal) 6q (interstitial)	
Oreolalax popei	all 13 centric all 13 terminal 6q (interstitial)*herozygesity	
Oreolalax rugosa	all 13 centric 6q (interstitial)	
Oreolalax schmidti	6q (interstitial)	6q (interstitial)

Mountains region. In this unusual geographic region, anura often have special chromosomal karyotypes. In addition to uncommon karyotypes reported in Ranidae (Wu and Zhao 1984a,b) unusual karyotypes were found in pelobatids where one of four *Atympanophrys shapingensis* examined was found to be triploid and the karyotype of the single female *Megophrys lateralis* studied was 2n+1 (Wu 1987).

2. Karyotypes.

Morescalchi (1973) concludes that two main karyotype formulae are found in the family Pelobatidae. The first consists of 6 pairs of large and 7 pairs of small chromosomes. The second consists of 5 pairs of large and 8 pairs of small chromosomes. Chinese pelobatids are divided into two subfamilies: Oreolalaxinae and Megophryinae. The majority of the species studied in the Oreolalaxinae have the first formula (6+7), and most of the chromosomes are 2n=26 with metacentric, submetacentric, or subtelocentric chromosomes (NF=52)[see Table 3]. Only *O. schmidti* reported on in this paper has the second formula (5+8) and NF=50. In the Megophryinae, the karyotype is variable in the four species studied (Table 3). *Atympanophrys shapingensis* has a karyotype formula of 5+8 with NF=52, *B. carienensis* has a formula of 5+8 with NF=52, *M. lateralis* has 6+7 with NF=52,

and *M. omeimontis* has 5+8 with NF=48. It is widely believed that species with fewer numbers of NF (possessing more pairs of homologous with telocentric and small chromosomes) are more primitive (Schmid, 1978a). For this reason, we speculate that *M. omeimontis* and *Brachytarsophrys carinensis* are more primitive in karyotype evolution.

In the evolution of Amphibia, the rate of gene mutation is more rapid than karyotype mutation. The form of the gene mutation is revealed by the secondary constriction (SC). Compared with the more advanced groups like ranids and hylids, the number of SC in pelobatids is fewer, only one or two. In 10 of 14 species listed in table 3, the SC is found on the no. 6 chromosome long arm. We consider the frequent presence of the SC on the long arm of no. 6 chromosome an indication of genetic stability in Pelobatidae. Furthermore the SC which. is on no. 5p in *M. lateralis,* 9q in *Brachytarsophrys carinensis*,1q in *Atympanophrys shapingensis*, and 2p in *Scutiger boulengeri* probably forms from pericentric inversions of chromosomes, or chromosome segment translocation. We speculate these species are more developed in genetic phylogeny.

3. C-bands and NORs.

Not only are the pelobatids classified as primitive through morphological taxonomy, but they are also ancestral in the character of the constitutive heterochromatin which is shown by C-bands (see Table 4). The C-bands, which are found mainly at centromeres and telomeres, are lower in number in pelobatids than in the more advanced ranids and hylids. In *M. omeimontis* there is a centric C-band on every pair of chromosomes in addition to one inter-C-band on the 6q. However, *O. schmidti* has only one inter-C-band on the 6q and no bands on the others, indicating it's genetic stability.

It is speculated that karyotypes with a single large NOR pair are more ancestral than those in which the NORs are distributed over several chromosomes (Hsu 1975). Some species of ranids have several additional small NORs instead of a large NOR (Schmid 1978b). Schmid suggests that the single large NOR which appears ancestral would have been transferred to other chromosomes as complete packages, rather than as multiple smaller units distributed throughout the genome by translocations and inversions (Schmid 1978a).

M. lateralis (Wu 1987), *M. omeimontis* and *O. schmidti* (in this paper) all have only a large NOR. This suggests that pelobatids are more primitive that ranids. As illustrated in tables 3 and 4, most of the 14 species of Chinese pelobatids that have been studied have the conspicuous SC on the no. 6q, along with the strongly C-band-positive. In addition, this is associated with the NORs in *M. omeimontis* and *O. schmidti*. We suggest that this position of the constitutive heterochromatin must have been primitive. It is a character of genetic stability in the pelobatids. It is indicated that pelobatids without this character have genetic constriction altered during the evolutionary prosses.

M. omeimontis and *O. schmidti* appear to be primitive both by C-banding and Ag-NORs banding. Although the morphological characters are different, both species possess extremely similar karyotypic characters.

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Karyotypic Analyses of Four Species in Four Genera of Colubrid Snakes

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Abstract. -The karyotypes are presented for four species, belonging to different genera in the snake family Colubridae. *Pseudoxenodon macrops sinensis* has 2n=38 with 8 pairs of macrochromosomes and 11 pairs of microchromosomes. The diploid number of *Dinodon rufozonatum* is 2n=46 with 8 pairs of macrochromosomes and 15 pairs of microchromosomes. *Elaphe mandarina* has 2n=38 with 8 pairs of macrochromosomes and 11 pairs of microchromosomes. *Zaocys nigromarginatus* has 2n=34 with 8 pairs of macrochromosomes and 9 pairs of microchromosomes. The relationship between karyotype and phylogeny is discussed.

Key words: Cytotaxonomy, Colubridae, *Pseudoxenodon, Dinodon, Elaphe, Zaocys,* China

TABLE. 1. The diploid chromosome number of the four colubrid snake species.

Species	No. of Cells Observed	2n	% of 2n Cells
Dinodon rufozonatum	40	46	65.7
Elaphe mandarina	98	38	59.1
Pseudoxenodon macrops sinensis	100	38	60.0
Zaocys nigromarginatus	111	34	77.5

Introduction

The family Colubridae is a large and phylogenetically complex group of serpents, including 37 genera and 144 species in China. Various karyotypic data on Colubridae have been reported. This paper presents the karyotypes of four species in the family: *Pseudoxenodon macrops sinensis* Boulenger, *Dinodon rufozonatum* (Cantor), *Elaphe mandarina* (Cantor), and *Zaocys nigromarginatus* (Blyth).

Methods

Pseudoxenodon macrops sinensis (2 males), *Dinodon rufozonatum* (1 female), *Elaphe mandarina* (2 males) and *Zaocys nigromarginatus* (4 males) were purchased in July, 1986 from Miyi County (26° 50' N 102° 03' E), Dukou Municipality, Sichuan Province, China. The specimens were sacrificed after intraperitoneal injection of 1mg/ml colchicine (5mg/gr body weight). Partial spines and ribs were taken out, from which the bone marrow was flushed with 1% sodium citrate and the cell suspension was treated hypotonically (0.4% KCL) for half an hour at room temperature, fixed in a fresh fixative (ethanol:glacial acetic acid = 3:1) after centrifuging for 7 min. at 1000 rpm, and stored in the fixative over night at 4 °C. Then the chromosome preparations were made using an air-drying technique, stained for 30-40 min in 10% Giemsa, and observed under an oil objective for counting and microphotographing the chromosomes. The relative length and arm

ratio of chromosomes were calculated according to the method proposed by Singh (1972). Classification of chromosomes follows Levan et al. (1964).

Results

The chromosome data, including diploid number, and morphology, relative length and arm ratio for the macrochromosomes of the four species are shown in Table 1 and Table 2.

Pseudoxenodon macrops sinensis. The diploid number is 38 with 8 pairs of macrochromosomes and 11 pairs of microchromosomes. There are 5 pairs of metacentric chromosomes (nos. 1-5) and 3 pairs of submetacentric chromosomes (Nos. 6-8) among the macrochromosomes.

Dinodon rufozonatum. The diploid number is 46 with 8 pairs of macrochromosomes and 15 pairs of microchromosomes. Among the macrochromosomes, pair 1 is submetacentric, and the heteromorphic third pair should probably be considered to be sex elements. However this can't be proven since only one female and no males were examined. The Z chromosome is metacentric and the W chromosome is submetacentric, with the Z longer than the W. The rest of the macrochromosomes are acrocentric (Fig. 2).

Elaphe mandarina. The diploid number is 38, and the karyotype is readily divided into 8 pairs of macrochromosomes and 11 pairs of microchromosomes. For the macrochromosomes, Pairs 1-4 are metacentric, pairs 5 and 6 submetacentric and pairs 7 and 8 acrocentric (Fig. 3).

Zaocys nigromarginatus. The diploid number is 34 with 8 pairs of macrochromosomes, in which nos. 1, 3-4, and 6 are metacentric and the rest submetacentric. There are 9 pairs of microchromosomes (Fig. 4).

Discussion

The diploid chromosome number in the family Colubridae ranges from 24 to 50. The most commonly observed karyotype is 2n=36 with 8 pairs of macrochromosomes and 10 pairs of microchromosomes. There is a distinction between macro- and microchromosomes (Gorman, 1973). In general, the difference in diploid number might be caused by a variation in number of microchromosomes. However, there are exceptions. For instance, *Amphiesma stolata* has 7 pairs of macrochromosomes (Singh, 1972), *Natrix erythrogaster* has 16 pairs, and both *N. harteri* and *N. rhombifera* have 17 pairs (Baker et al. 1972). Based on the Robertsonian translocation about chromosome evolution, the karyotypes with a large chromosome number, more microchromosomes and acrocentric chromosomes, are often considered to be primitive ones (Morescalchi et al. 1979). Some species of *Natrix* (sensu lato), which have more macrochromosomes and fewer microchromosomes, might be more advanced species.

A number of karyotypes of *Elaphe* have been reported. A karyotypic study of 3 species of Chinese *Elaphe* was done by Yang et al. (1986). Most species examined have a karyotype of 2n=36., however, the Chinese *E. bimaculata* has 2n=34, and the North American *E. subocularis* has 2n=40 (Baker et al. 1972). This paper reports the karyotype of *E. mandarina* which has 2n=38, including 8 pairs of macrochromosomes and 11 pairs of microchromosomes. The karyotype differs from other studied species of *Elaphe,* not only in number of microchromosomes (22, instead of 20), but also in the morphology of the macrochromosomes (2 pairs of acrocentric chromosomes, not 1 pair) [Table 3]. As described above, there are interspecific differences in *Elaphe*. One of the present authors (Zhang 1988) divided the genus into three groups based on the morphological characters of the skeleton, muscles, and hemipenes. *E. carinata* differs from the other species of *Elaphe* in these morphological characters but not in its karyotype. On the contrary, there are karyotypical differences between *E. mandarina* and other species of *Elaphe,*

TABLE. 2. Macrochromosome data of the four colubrid snake species.

Chromosome no.	Relative Length	Arm Ratio	Centromere Position
	Dinodon rufozonayum	*Dinodon rufozonayum*	*Dinodon rufozonayum*
1	30.30 ± 1.41	1.91 ± 0.22	submetacentric
2	17.94 ± 1.11	-	telocentric
3(Z)	16.66 ± 1.19	1.63 ± 0.24	metacentric
3(W)	13.95 ± 0.73	2.27 ± 0.41	submetacentric
4	15.26 ± 1.11	-	telocentric
5	11.06 ± 1.00	-	telocentric
6	10.10 ± 0.51	-	telocentric
7	8.54 ± 0.70	-	telocentric
8	6.81 ± 0.61	-	telocentric
	Elaphe mandarina	*Elaphe mandarina*	*Elaphe mandarina*
1	25.36 ± 1.42	1.15 ± 0.12	metacentric
2	20.11 ± 0.91	1.62 ± 0.20	metacentric
3(Z)	15.41 ± 1.05	1.20 ± 0.20	metacentric
4	11.50 ± 0.60	1.32 + 0.16	metacentric
5	7.88 ± 0.71	2.12 ± 1.05	submetacentric
6	7.14 ± 0.68	1.94 ± 0.26	submetacentric
7	6.92 ± 0.54	-	telocentric
8	5.65 ± 0.69	-	telocentric
	Pseudoxenodon macrops	*Pseudoxenodon macrops*	*Pseudoxenodon macrops*
1	22.70 ± 1.55	1.16 ± 0.09	metacentric
2	19.04 ± 1.24	1.61 ± 0.18	metacentric
3(Z)	14.60 ± 1.33	1.30 ± 0.16	metacentric
4	11.01 ± 1.01	1.31 ± 0.12	metacentric
5	9.87 ± 0.44	1.44 ± 0.29	metacentric
6	8.48 ± 0.45	1.73 ± 0.41	submetacentric
7	7.49 ± 0.60	1.88 ± 0.40	submetacentric
8	6.82 ± 0.59	1.90 ± 0.69	submetacentric
	Zaocys nigromarginatus	*Zaocys nigromarginatus*	*Zaocys nigromarginatus*
1	23.04 ± 1.00	1.17 ± 0.11	metacentric
2	18.93 ± 1.25	1.72 ± 0.15	submetacentric
3(Z)	14.64 ± 1.10	1.25 ± 0.09	metacentric
4	10.76 ± 0.63	1.32 ± 0.14	metacentric
5	9.91 ± 0.33	2.10 ± 0.30	submetacentric
6	8.86 ± 0.44	1.24 ± 0.15	metacentric
7	7.34 ± 0.87	1.79 ± 0.29	submetacentric
8	6.52 ± 0.69	1.73 ± 0.36	submetacentric

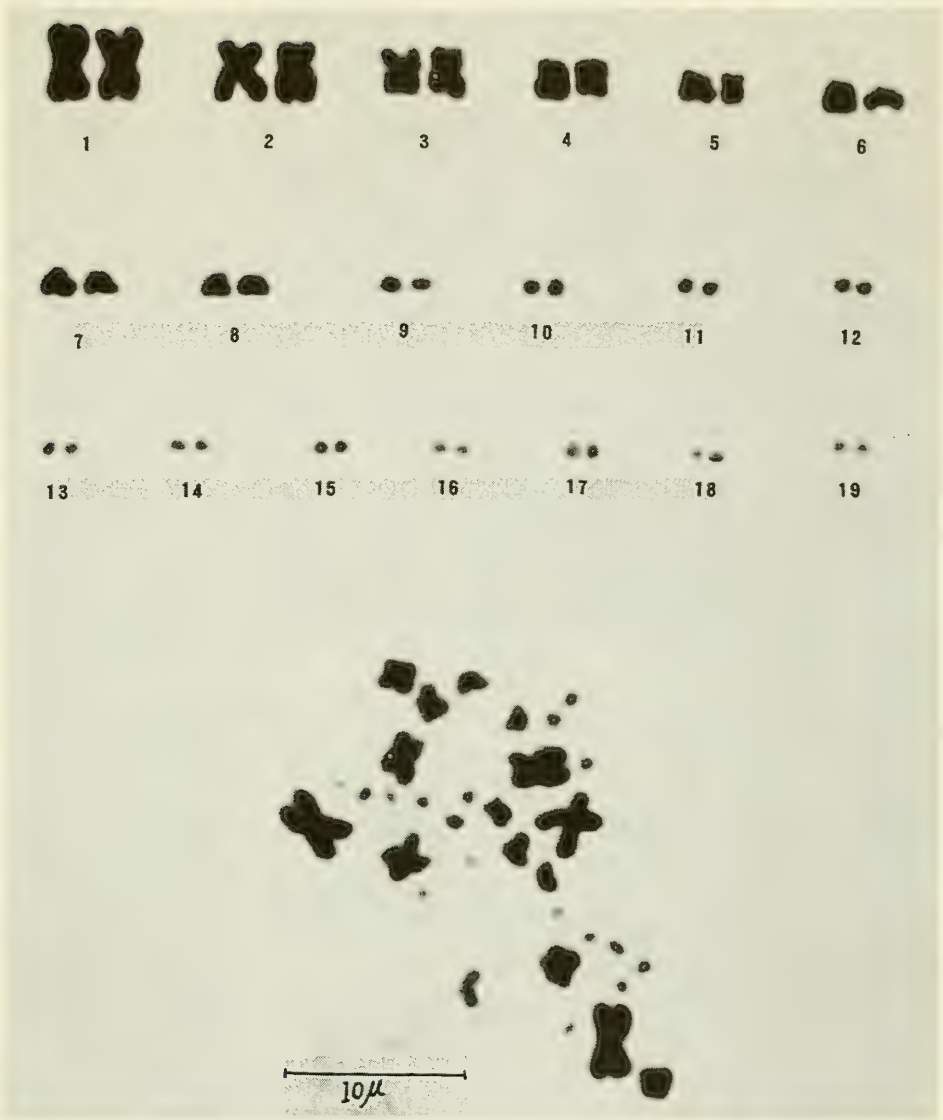

FIG. 1. Karyotype of *Pseudoxenodon macrops*, Female.

FIG. 2. Karyotype of *Dinodon rufozonayum*, Female.

FIG. 3. Karyotype of *Elaphe mandarina*, Male.

FIG. 4. Karyotype of *Zaocys nigromarginatus*, Female.

TABLE. 3. Karyotypic data of some species in the genus *Elaphe*, from China.

Species	2n	Macrochromosome	Microchromosome	Reference
Elaphe bimaculata	34	16(7M, 7S, &2A)	18	Xie et al. 1983
Elaphe carinata	36	16(7M, 7S, &2A)	20	Xie et al. 1983
Elaphe dione	36	16(7M, 7S, &2A)	20	Yang et al. 1986
Elaphe moellendorffi	36	16(7M, 7S, &2A)	20	Yang et al. 1986
Elaphe rufodorsata	36	16(7M, 7S, &2A)	20	Yang et al. 1986
Elaphe taeniura	36	16(7M, 7S, &2A)	20	Xie et al. 1983
Elaphe mandarina	38	16(8M, 4S, &4A)	22	here reported

while there are similarities in morphological characters between it and *E. rufodorsata* as well as *E. dione*.

We report the karyotype of *Dinodon rufozonatum*, which is consistent with that of the same species reported by Nakamura (1935) in diploid number and the numbers of macro- and microchromosomes (2n=46 with 8 pairs of macrochromosomes and 15 pairs of microchromosomes). However, there are differences in the morphology of the macrochromosomes. We found 6 pairs of acrocentric, 1 pair of submetacentric, and 1 pair of metacentric chromosomes. Nakamura found 7 pairs of acrocentric and 1 pair of metacentric chromosomes. The sex chromosomes in the majority of species of colubrids are the fourth largest pair (Yang et al. 1983; Zie et al. 1983; Baker et al. 1972). A female specimen of *D. rufozonatum* was studied by the present authors and clear heteromorphism was detected in the third largest pair, which might indicate a sex chromosome. Within Colubridae, *Clelia occipitolutea* has 2n=50, including 6 pairs of acrocentric, and 1 pair of metacentric chromosomes, *Oxyrophus petolaris* has 2n=46, with 5 pairs acrocentric, 2 pairs submetacentric, and 1 pair metacentric. *Macropisthodon rudis* has 2n=46 with 7 pairs acrocentric and one pair metacentric. These karyotypes suggest that the three species above and *D. rufozonatum* may be primitive species in the family Colubridae.

We found that the karyotype of *Zaocys nigromarginatus* is 2n=34, comprised of 8 pairs of macrochromosomes and 9 pairs of microchromosomes, while the karyotype of the same species, as reported by Nakamura (1935), had 2n=36 with 8 pairs of macrochromosomes and 10 pairs of microchromosones. More studies have to be completed in order to determine if these karyotypic differences show geographic patterns. There is a different diploid number between *Z. dhumnades* (2n=36, Yang et al. 1986) and *Z. nigromarginatus* (2n=34), but the morphology of the macrochromosomes is similar except for pairs 4 and 5. The fourth pair is metacentric and the fifth pair is submetacentric in *Z. dhummnades*, whereas the fourth pair is submetacentric and the fifth pair is metacentric in *Z. nigromarginatus*.

The karyotype of *Pseudoxenodon macrops sinensis* is 2n=38, with one more pair of microchromosomes than the typical karyotype of colubrid snakes (2n=36). There are 5 pairs of metacentric and 3 pairs of submetacentric macrochromosomes. It does not appear to be a primitive species.

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Karyotypic studies of *Sphenomorphus indicus* (Scincidae) and *Takydromus septentrionalis* (Lacertidae)

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Abstract. -*Sphenomorphus indicus* (Gray) has a diploid number of 28 with 14 metacentric macrochromosomes and 14 microchromosomes. The NF value is 42. *Takydromus septentrionalis* (Guenther) has a karyotype with 36 acrocentric macrochromosomes and only 2 microchromosomes (2n=38). The NF value is 38. These karyotypic data are compared with related species.

Key words: Sauria, Scincidae, Lacertidae, *Sphenomorphus*, *Takydromus*, Cytotaxonomy, Sichuan, China.

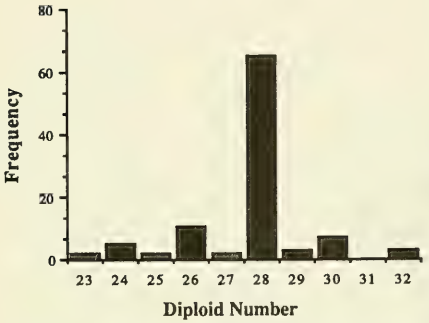

FIG. 1. *Sphenomorphus indicus* has a diploid chromosome number of 28. This was determined by counting the mitotic metaphase chromosomes of 100 individual cells.

Introduction

The karyotypes of two species of lizards, *Sphenomorphus indicus* (Gray) in the family Scincidae and *Takydromus septentrionalis* in the family Lacertidae are reported in this paper.

Methods

Sphenomorphus indicus (1 male and 1 female) and *Takydromus septentrionalis* (1 male and 1 female) were collected in June, 1978 from An Xian County (31° 40' N 104° 26' E), Mianyang Prefecture, Sichuan Province, China.

The specimens were injected intraperitoneally with 0.01 ml colchicine solution (3mg/ml) per gram of body weight. Sixteen hours after the injection, he specimens were killed. The bone marrow cells were flushed with 1% sodium citrate, the testes were removed, and cell suspensions were prepared. Then the chromosome preparations were made using an air-drying technique.

The diploid number (2n) was determined by observing the preparations under an oil objective. Ten selected cells were photographed, enlarged, and measured for calculating the chromosome parameters. The chromosomes were classified with the standard proposed by Levan et al. (1964). The abbreviations for the morphology of chromosomes are as follows: "M" is used for a macrochromosome, "m" for a microchromosome, "V" for a metacentric chromosome and "I" for an acrocentric chromosome. The "Nombre Fondamental" (NF) is the total number of arms in the karyotype. A metacentric (V) has two arms, an acrocentric (I) has one arm, and a microchromosome is also considered to have one arm regardless of its morphology.

Results

Sphenomorphus indicus (Gray). The diploid number is 28 consisting of 14V+14m, NF=42 (Table 1, Figs. 1 and 2). In addition to mitotic metaphase cells, numerous diakineses were seen in the males, having 7 macrobivalents and 7

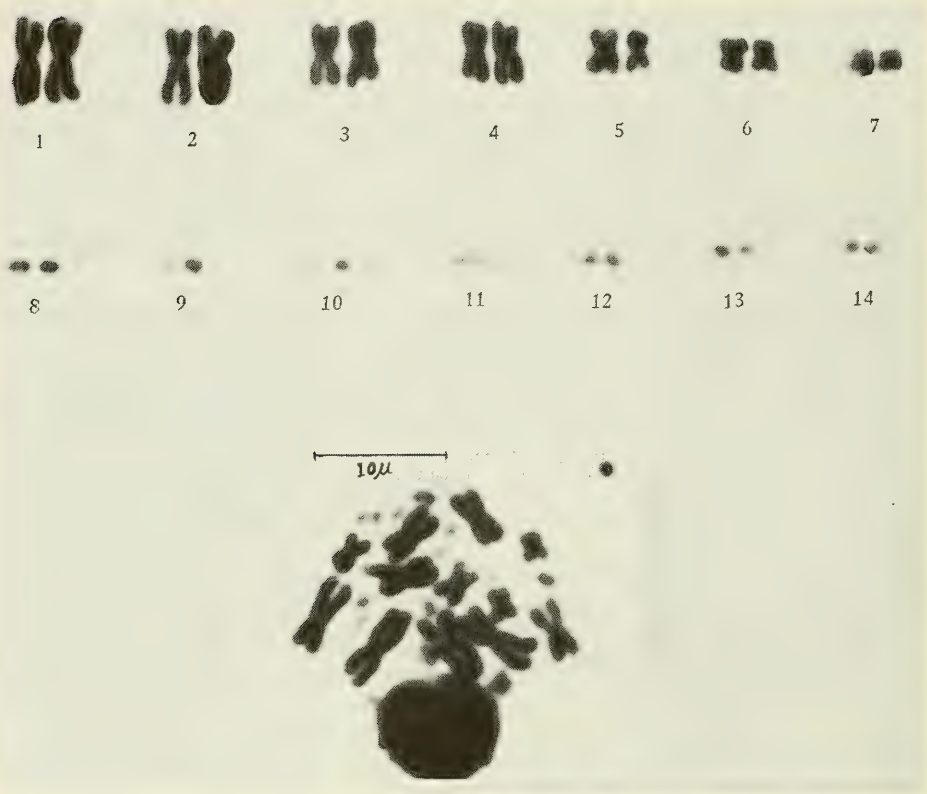

FIG. 2. The chromosomes of *Sphenomorphus indicus*. There are seven pairs of metacentric macrochromosomes and seven pairs of microchromosomes.

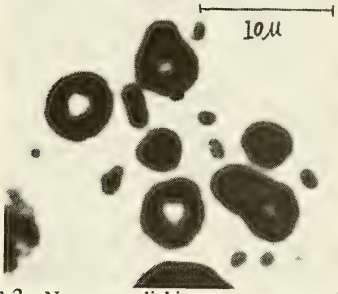

FIG 3. Numerous diakineses are present in the testes cells of male *Sphenomorphus indicus*.

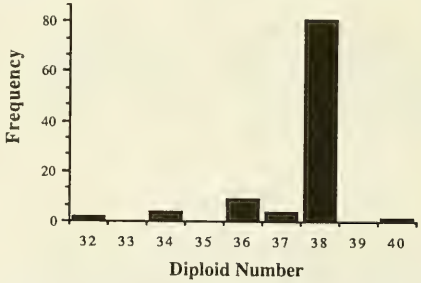

FIG. 4. *Takydromus septentrionalis* has a diploid chromosome number of 38. This was determined by counting the mitotic metaphase chromosomes of 100 individual cells.

TABLE 1. Data on chromosome number, relative length, arm ratio, and centromere position for *Sphenomorphus indicus* (Scincidae) and *Takydromus septentrionalis* (Lacertidae).

Chromosome no.	Relative Length	Arm Ratio	Centromere Position
	Sphenomorphus indicus	*Sphenomorphus indicus*	*Sphenomorphus indicus*
1	21.83 ± 1.22	1.3 ± 0.1	Metacentric
2	19.14 ± 0.77	1.3 ± 0.1	Metacentric
3	16.19 ± 0.44	1.1 ± 0.1	Metacentric
4	15.32 ± 0.65	1.2 ± 0.2	Metacentric
5	11.62 ± 1.34	1.2 ± 0.2	Metacentric
6	08.98 ± 0.85	1.2 ± 0.1	Metacentric
7	06.83 ± 1.01	1.3 ± 0.3	Metacentric
	Takydromus septentrionalis	*Takydromus septentrionalis*	*Takydromus septentrionalis*
1	9.43 ± 0.80	> 0.70	Telocentric
2	8.69 ± 0.58	> 0.70	Telocentric
3	8.15 ± 0.38	> 0.70	Telocentric
4	7.56 ± 0.46	> 0.70	Telocentric
5	6.71 ± 0.32	> 0.70	Telocentric
6	6.43 ± 0.29	> 0.70	Telocentric
7	6.23 ± 0.26	> 0.70	Telocentric
8	5.76 ± 0.37	> 0.70	Telocentric
9	5.55 ± 0.34	> 0.70	Telocentric
10	5.09 ± 0.31	> 0.70	Telocentric
11	4.78 ± 0.36	> 0.70	Telocentric
12	4.46 ± 0.37	> 0.70	Telocentric
13	4.12 ± 0.21	> 0.70	Telocentric
14	3.97 ± 0.21	> 0.70	Telocentric
15	3.65 ± 0.24	> 0.70	Telocentric
16	3.39 ± 0.21	> 0.70	Telocentric
17	3.28 ± 0.16	> 0.70	Telocentric
18	2.80 ± 0.29	> 0.70	Telocentric

microbivalents (n=14) [Fig. 3].

Takydromus septentrionalis (Guenther). The diploid number is 38 with 36I and 2m, NF=38 (Table 1, Figs. 4 and 5). The diakineses were observed in males, containing 18 macrobivalents and only one microbivalent (Fig. 6).

Discussion

Sphenomorphus indicus and *Takydromus septentrionalis* belong to two different families. and there are distinct differences between their karyotypes. The former has 14V+14m with the ratio of M:m being 14:14, while the latter has 36I+2m with the ratio of M:m being 36:2. It is obvious that their karyotypic difference is consistent with the distance in their phylogenies.

King (1981) suggested that some groups of lizards are chromosomally conservative, whereas others are extraordinarily diverse.

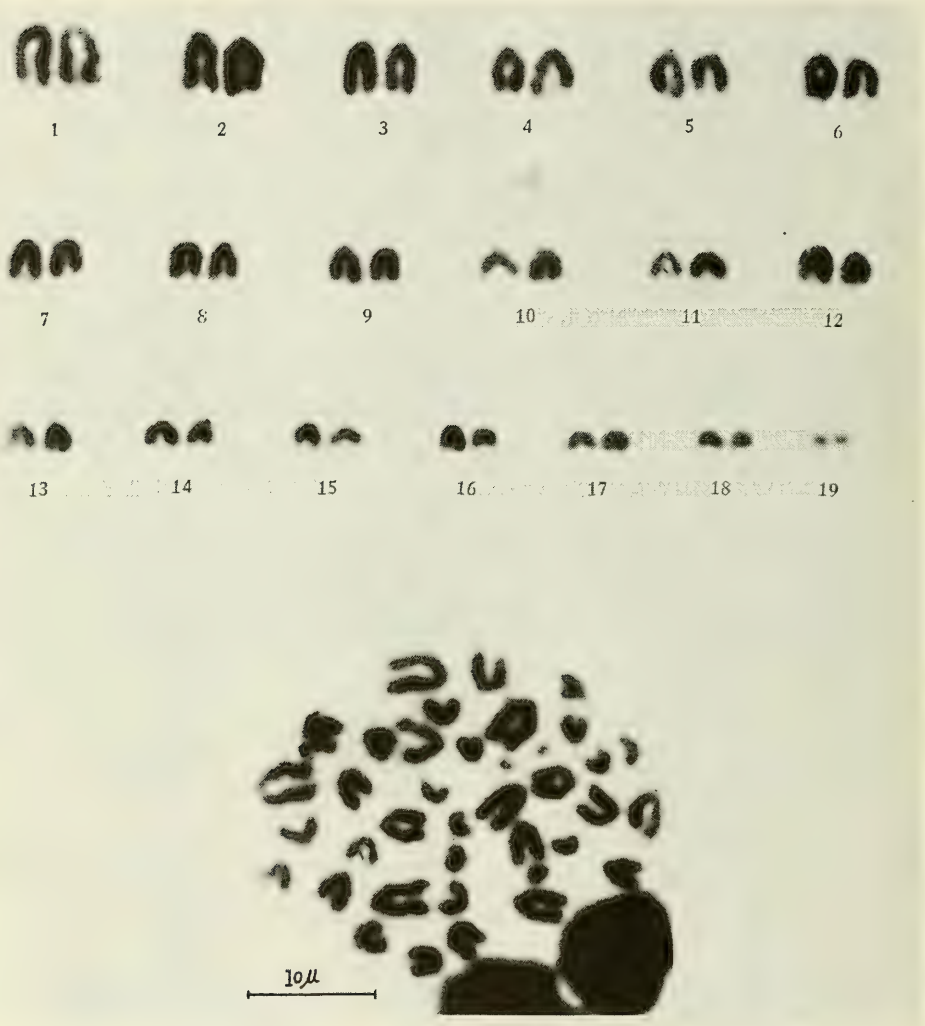

FIG. 5. The chromosomes of *Takydromus septentrionalis*. There are eighteen pairs of acrocentric macrochromosomes and one pair of microchromosomes.

The karyotype data from 7 genera, 19 species of Scincidae (Gorman, 1973) show that the diploid numbers vary, including 24, 26, 28, 30, and 32 with the ratio of M:m variable ranging from 8:20 to 12:12. Additionally, the karyotype is not readily divisible into macro- and microchromosomes for some species. The variation is found not only at the species or genus level, but also in different local

FIG. 6. Only one microbivalent chromosome (shown by the arrow) is present in the testes of male *Takydromus septentrionalis.*

populations of the same species. For example, Makino and Momma (1949) reported that the karyotype of *Sphenomorphus indicus* is 2n=28 with 10V+18m and the ratio of M:m being 10:18. The karyotype of the same species reported by the present authors has a diploid number of 28 with 14V+14m and the ratio of M:m is 14:14. This appears to be an unreported karyotype pattern in the Scincidae. On the other hand, the chromosomal data of 7 genera, 32 species or Lacertidae (Gorman 1973) reveal that the family's karyotypes are conservative, having a diploid number of 38 with 36I and 2m, except for a few species. The karyotype of *Takydromus septentrionalis* is 2n=38 comprised of 36I and 2m, which agrees with that of the *T. septentrionalis* reported on by Nakamura (1935). It appears that there is no geographical variation between the two populations of *T. septentrionalis.*

Lizards vary markedly in their karyotypic evolution (Gorman 1973, King 1981) and consisted of 331 genera and 3105 species as of Underwood (1957). It will reveal valuable insights into the evolution of lizards to study their karyotypes deeply and widely.

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Mimicry of Scorpions by Juvenile Lizards, *Teratoscincus roborowskii* (Gekkonidae)

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Abstract. -*Teratoscincus roborowskii* is a large nocturnal gecko that occurs only in the Turpan Depression of northwestern China. The striking similarity of dorsal coloration, escape behavior, and body size of juvenile *T. roborowskii* and a species of scorpion in the genus *Mesobuthus* (Bathidae) indicates probable Batesian mimicry by these lizards.

Key Words: Batesian mimicry, lizards, Gekkonidae, *Teratoscincus*, scorpions, China.

Introduction

Batesian mimicry is a well-documented phenomenon in both invertebrates and vertebrates (See Pough 1988a, 1988b for review of vertebrate mimicry). In the simplest case, three organisms are included in a Batesian mimetic relationship: 1) a noxious or potentially dangerous MODEL; 2) an edible and relatively harmless MIMIC; and 3) a potential predator of both model and mimic, the DUPE (Pasteur 1982, Pough 1988a, 1988b). Rejection of the model as a prey item confers an adaptive advantage to the dupe, which manifests itself in a learned or instinctive avoidance of the model. A superficial similarity to the model should be adaptive to other organisms preyed upon by the dupe; hence a mimetic relationship evolves (Bobisud and Potratz 1976, Turner 1988).

Mimicry in lizards is poorly documented and largely anecdotal (Pough 1988a, 1988b, 1989 pers. comm., Parker and Pianka 1974, Huey and Pianka 1977). Our account is anecdotal as well, and we hope that as more examples of lizard mimicry surface, solid scientific studies will follow.

We present a case of probable Batesian mimicry between juvenile *Teratoscincus roborowskii* (Gekkonidae) and a scorpion in the genus *Mesobuthus* (Bathidae). *Teratoscincus roborowskii* occurs only in the second lowest spot on Earth (-154 m.), the Turpan Depression, Xinjiang Uygur Autonomous Region, China (taxonomy after Macey et al. in prep). Sympatric with *T. roborowskii* is the scorpion, *Mesobuthus* sp. It was the superficial similarity between *Mesobuthus* sp. and juvenile *T. roborowskii*, and indeed our care in making a proper identification when collecting the lizards, that first suggested mimicry.

Methods

During the 1987 and 1988 cooperative Chengdu Institute of Biology, University of California, California Academy of Sciences herpetological expeditions to the deserts of western China, we observed and collected *Teratoscincus roborowskii* in the Turpan area. The study area was 4.4 km west of the Main Mosque in Turpan (42°58'N 89°10'E), on the Turpan-Jiaohe road, Turpan Prefecture, Xinjiang Uygur Autonomous Region, China. This area consists of a series of rocky hills with sparse vegetation -primarily *Alhagi sparsiflora* (Leguminosae). This was the same study area that was used by Autumn and Wang (1988). The scorpion, *Mesobuthus* sp., is common on the site and can be easily collected by turning rocks. The scorpion specimens were donated to the California Academy of Sciences. The lizard specimens were donated to the Museum of Vertebrate Zoology and to the California Academy of Sciences.

In order to compare *T. roborowskii* with the other *Teratoscincus* species, we

examined *T. przewalskii* from Dunhuang, Gansu Province, China, *T. bedriagai* from the Siesitan Basin, Iran, and *T. microlepis* and *T. scincus* from the Helmud Basin, Afghanistan. None of these species are sympatric with *T. roborowski*. These specimens were provided by the Museum of Vertebrate Zoology, and by the California Academy of Sciences.

Results

Teratoscincus roborowskii was extremely common on the study site. While holding a bright flashlight at shoulder height and turning in a full circle, we often observed over 40 eyeshines at a single spot. The geckos remain motionless on open ground, a short distance from their burrows. They seem to be solitary, and adults and juveniles were never observed together.

The similarity between juvenile *T. roborowskii* and *Mesobuthus* sp. is evident in the dorsal coloration, size, defensive posture, and escape behavior of the two animals:

1. Dorsal coloration.

Juvenile *T. roborowskii* are banded from head to tail (Fig. 1). These bands are dark, thin, and are only present on the dorsal surface. This banding is lost in the adult. The number of bands on the body ranges from 5 to 8, with a mode of 7. The number of bands on a non-regenerate tail ranges from 4 to 6, with a mode of 5. Similarly, *Mesobuthus* sp. has 7 plates on the body and 5 segments on the tail (excluding the stinger, which is folded back) [Fig. 2, Fig. 3]. When viewed under moonlight, the patterns of the two animals are extremely difficult to differentiate.

2. Size.

The mean snout-vent length of juvenile *T. roborowskii* is 42 mm (N = 43, SD = 4.1, range: 35-53 mm). The mean non-regenerate tail length is 27 mm. (N = 39, SD = 2.1, range: 23-37 mm). The mean total length is 69 mm. (N = 39, SD = 5.65, range: 58-90 mm.) The largest *Mesobuthus* sp. we collected had a body length of 30 mm and a tail length of 37 mm., for a total length of 67 mm.

3. Defensive posture.

When provoked (by humans), juvenile *T. roborowskii* stiffen the body and raise the tail in an arc. This is in contrast to the adults, which adopt an arched posture and wave the tail from side to side, producing hissing noise from the specialized caudal scales, as demonstrated by Werner (1967). The defensive posture of *Mesobuthus* sp. is typical of most scorpions. The legs and pedipalps are extended and the tail is held in an arc above the abdomen. This arc is similar in form to that seen in the juvenile *T. roborowskii*

4. Escape behavior.

When approached, juvenile *T. roborowskii* scuttle quickly away -usually in a straight line- and stop a short distance away. The defensive posture mentioned above is usually maintained throughout flight. In contrast, adult *T. roborowskii* run for much longer distances, in a zig-zag pattern, and the body is thrown from side to side during flight. Both adults and juveniles will hide under *Alhagi sparsiflora* clumps or retreat into burrows if pursued. *Mesobuthus* sp. also run in approximately straight lines, for short distances.

The juvenile *T. scincus* we examined had 5 dorsal bands on the body and 5 thin dorsal bands on the tail. These specimens were the most similar in dorsal coloration to juvenile *T. roborowskii* and to *Mesobuthus* sp. The other *Teratoscincus* species specimens either had bands that were too broad or too few in number to accurately resemble scorpions. The juvenile *T.*

FIG. 1. Juvenile *Teratoscincus roborowskii* assuming a defensive posture while being photographed at night in the Turpan Depression, Xinjiang Uygur Autonomous Region, China, Sept. 10, 1988. This individual has 13 dorsal bands.

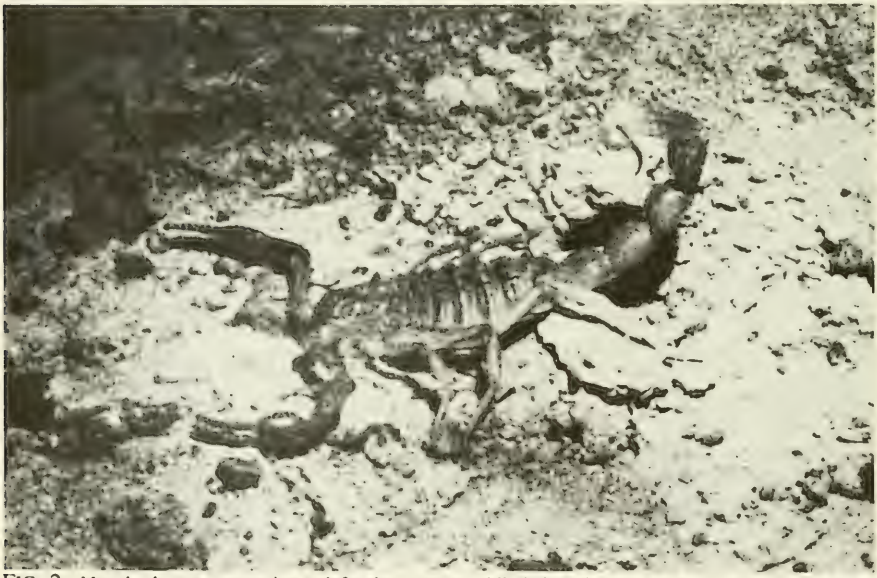

FIG. 2. *Mesobuthus* sp. assuming a defensive posture while being photographed at night in the Turpan Depression, Xinjiang Uygur Autonomous Region, China, Sep 10, 1988. This species has 13 obvious body and tail segments.

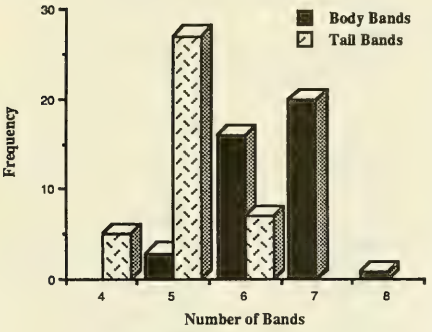

FIG. 3. Number of body and tail bands occurring in *Teratoscincus roborowskii* in the Turpan Basin. The mode of the body bands is 7 and the mode of the tail bands is 5. Similarly, the scorpion *Mesobuthus* sp., has 7 body segments and 5 tail segments.

przewalskii had 6-7 dorsal bands on the body and 2-4 broad dorsal bands on the tail. The juvenile *T. bedriagai* were unevenly banded on the body, and had 2 broad bands on the tail. Juvenile *T. microlepis* were mottled, with light bands on the body, and 7 light, uneven bands on the tail.

Discussion

Since tail-raising and arching is a common defensive behavior in other *Teratoscincus* (Mebs 1966), and other gekkonids as well (Bustard 1967, Johnson and Brodie 1974, Parker and Pianka 1974, Marcellini 1977, Vitt, et al 1977, Greene pers. comm., Huntley pers. comm), it may be an ancestral trait shared by most gekkonids, rather than a mimetic derivation in juvenile *Teratoscincus roborowskii*. Tail-raising and the possibly conspicuous tail-banding may misdirect the predator's attention to the readily autotomized tail (Pough 1988a, 1988b, Johnson and Brodie 1974, Parker and Pianka 1974, Vitt et al. 1977, Dial and Fitzpatrick 1981, Greene 1988 and Arnold 1988 for reviews).

However, 1) the behavioral differences of juvenile *T. roborowskii*, when compared with adults, 2) their similarity in dorsal coloration, size, defensive posture, and escape behavior to *Mesobuthus* sp., and 3) their relative availability to potential predators strongly indicates a mimetic relationship. Juvenile *T. roborowskii* differ greatly from other *Teratoscincus* juveniles in dorsal coloration. Only *T. roborowskii* and *T. scincus* possess thin dorsal bands that resemble scorpion segments. Furthermore, the kinematics of tail raising in juvenile *T. roborowskii* is not the same as that in *Coleonyx variegatus, C. brevis* (see Vitt, et al. 1977, p.328, and Dial and Fitzpatrick 1981 p.311 for figures), adult *T. roborowskii*. and adult *T. scincus* (Autumn, pers. obs., Mebs 1966 p. 17, 19 for figures). While juvenile *T. roborowskii* maintain a relatively rigid posture with the tail raised and parallel to the body, *Coleonyx* and adult *Teratoscincus* adopt an arched posture and wave the tail. It is plausible that the evolution of scorpion mimicry in juvenile *T. roborowskii* was made possible by the ancestral banding and postural characters.

Candidates for the dupe include the little owl, *Athene noctua* (de Schauensee 1984), the red fox, *Vulpes vulpes* (Tate 1947), the sand boa, *Eryx tataricus*, and adult *Teratoscincus roborowskii*. Macey and Papenfuss (1986 pers. comm) reported that several adult *T. roborowskii* had regurgitated undigested juvenile *T. roborowskii* while in a sack. Adults and juveniles were kept together and it is likely that predation took place in the sack.

Juvenile *T. roborowskii* may not able to function as mimics throughout their activity period. Unless the mimicry is tactile as well, the similarity should only be present while the lizards are out of their burrows and are in sufficient light, as is present during moonlit hours. However, the selective advantage should still be substantial if moonlight provides the greatest mimetic protection during a period when predation pressure by visual predators is likely to be the highest.

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New Locality Records for Chinese Non-Marine Chelonians

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Introduction

In the past decade field biology has enjoyed a renaissance in China. Distributional information concerning a wide range of reptiles and amphibians in the People's Republic of China has been updated and recorded. Prior geographical distribution data often predate the Second World War, and the current generation of Chinese herpetologists has published their findings mostly in Chinese language journals with limited overseas circulation. Even in those cases where an English summary is provided, the translated information is usually less complete than the original Chinese. Changes in the English rendition of localities in China has been an additional problem. What follows are several new localities published since 1973 for 12 species of Chinese turtles representing 4 families.

Classification is in accordance with the latest revisions (see Iverson 1986, and Iverson and McCord 1988). Where controversy exists, the classification given in the Chinese journal is presented parenthetically following the current approved classification. Province (in capitals) and locality are given following each species. The rendering of Chinese localities and authors' names is in accordance with the current Pinyin standard; therefore, hyphens have been deleted from names and localities prior to 1983. The nature of the record (literature, collection, purchase) is indicated along with other parameters, if given. The geographical significance of the new records is discussed, and habitat information, if given in the original paper, is presented. In 2 cases (*Testudo horsfieldii* and *Manouria impressa*) specific locality information lacking in the original texts was provided via personal communication from Ermi Zhao The order of species follows Iverson (1986).

Family Emydidae

Chinemys reevesii: SHAANXI: Shangnan. Song and Fang, 1982. Iverson (1986) shows 2 localities in central Shaanxi, one of which is apparently Xi'an. Shangnan is about 110 km SW Xi'an. ANHUI: Changling Commune, Jinzhai Co. and Puoliangtin Commune, Shu shuong Co., Dabie Shan. Zou, 1983. Lovich et al. (1985) list 28 Anhui specimens in 2 American museums. The Dabie Shan localities are more than 100 km W of the Anhui localities plotted by Iverson (1986), and are the first for that province north of the Chang Jiang (Yangtze River). JIANGXI: Lu shan (literature record); Nanchang (1 specimen collected by author); Anfu (specimen documented but not located). Zhong and Wu, 1981. Lovich et al. (1985) refer to 13 specimens from Jiansu (sic) in 4 American museums. ZHEJIANG: coastal isles and part of Zhoushan Qundao, Dinghai Co. Gu et al, 1982. Lovich et al. (1985) cite 13 specimens from Zhejiang in 2 American museums. Additionally, they list 4 specimens (CAS) from Chusan Island (Zhoushan Qundao), which they list as a province.

Chinemys nigricans (Chinemys kwangtungensis): GUANGXI: Nanning and Liuzhou. Zong and Ma, 1985. Eleven specimens in the Shanghai Museum of Natural History. Carapace lengths (CL) range from 123 to 257 mm. Two black and white figures showing head, plastrons. The Guangxi localities represent range extensions of approximately 320 and 130 km W and WNW Wuzhou, heretofore the only published Guangxi locality. Iverson and McCord (1988) show *C. kwangtungensis* to be an invalid taxon.

Cistoclemmys flavomarginata (Cuora flavomarginata): GUANGXI: Wuzhou. Wen, 1983. Guangxi Medical College 81014. An adult of unspecified gender whose CL is 165 mm. First provincial record. Extends range approximately 180 km W Guangzhou, Guangdong (Iverson 1986).

Cistoclemmys galbinifrons (Cuora hainanensis): HAINAN: Dali of Diaulo Shan; Nanxi of Diaulo Shan, and Chien Fung Ling. Hu et al., 1975. Nine specimens (4 males, 5 females) collected between 1957 and 1964, of which museum numbers are given for only 2 specimens, 64 III 6110 (Sichuan Biol. Res. Inst., now Chengdu Inst. Biol.), and FU 200. Altitudes given for Dali (200m) and Nanxi (82 m). First record for China. The brief description of "*Cuora hainanensis* " and comparison with *C. flavomarginata* in Hu's paper was misleading to Western readers, who concluded erroneously that it was a subspecies of the latter. Chinese herpetologists at the time were unfamiliar with *C. galbinifrons*, with which *C. hainanensis* is presently being synonymized (Zhao, in press). GUANGXI: Xiaodong village, Qin Prefecture. Liu and Zhang, 1987. Two female specimens, Chengdu Inst. Biol. 8601 and Guangxi Aquatic Products Inst. 8602, purchased in Nanning farmer's market on 3/19/86 and 8/22/86, respectively. Identified by Ermi. Zhao. Several dimensions and mass of these specimens given. Another 22 specimens, whose fate is not specified, were purchased in the farmer's market. All were said to have been found in a ravine near Xiaodong village. First provincial record and first record for mainland China. Until 1975 (Hu et. al) this species was known from only 3 localities in northern Vietnam (Petzold 1965), the nearest of which, Tam Dao, is approximately 380 km WSW Xiaodong village.

Cuora pani: SHAANXI: Xujiaba, Pingli Co. Song, 1984. Holotype Shaanxi Inst. Zool. 80170 (male), allotype SIZ 80171 (female). New species, and a NE range extension for the genus by approximately 900 km (Yunnan Fu, Yunnan, for *C. yunnanensis*). Two figures (showing carapace and plastron), several dimensions and ratios are given in this description which contrasts the new taxon with *C. yunnanensis* without mention of *C. trifasciata* to which *pani* bears a stronger resemblance. Several specimens of box turtles identified as *C. pani* have entered the United States and Europe via the pet trade, their geographical origin a mystery to the purchaser. In his redescription of *C. pani*, Ernst (1988) used15 pet trade animals of unstated origin, and relied upon an incomplete translation of Song's paper. The plastral pattern of the turtle in Ernst's figure 3 is remarkably different from that of the holotype (Song 1984). It is possible that future research will reveal that *C. pani* and other new taxa of Chinese box turtles being described from a very small sample are no more different from *C. trifasciata* than are the races of *Terrapene carolina* from one another.

Mauremys mutica (Clemmys mutica): ZHEJIANG: coastal isles and part of Zhoushan Qundao, Dinghai Co. Gu et al., 1982. Zhoushan Qundao (Chusan Island) is the type locality for this species. GUANGXI: Tian Deng and Da Xin. Lin, 1985. Four unnumbered male specimens, 2 captured on 10/4/83 and 2 on 8/16/84. Dimensions and mass recorded. First provincial record, and first record between Guangzhou, approximately 600 km to the E (Iverson 1986) and Ha Tinh, Vietnam, approximately 350 km WSW (Petzold 1965).

Ocadia sinensis: GUANGXI: commune near Wuming. Lin, 1984. A dead male turtle weighing 1300 g was found on 4/13/83 and deposited in the Guangxi College Trad. Chin. Med. First provincial record, extending range approximately 450 km W Guangzhou.

Sacalia bealei (Clemmys quadriocellata): JIANGXI: Jiulanshan in Longnan Xian. Zhong, 1981. Two juveniles, Jiangxi Medical College 00183-4, collected in September 1979. Dimensions given. First provincial record, extending range

approximately 170 km NE Guangzhou (Iverson 1986).

Family Platysternidae

Platysternon megacephalum: JIANGXI: Qianshan (3 specimens collected by author); Pingxih; Longnan; Anfu; Pingxiang (specimens documented but not located); Xuniao (literature record). Zhong and Wu, 1981. First provincial records. Less than 200 km from known localities in neighboring Fujian, Guangdong, and Hunan.

Family Testudinidae

Testudo horsfieldii: XINJIANG: Lower Ili and Kax valleys near Yining, approximately 550 km W Urumqi. Zhao, 1973. Dimensions are given for SBRI (CIB) 625145-6, a male and female, respectively. First record for China. This tortoise may be present in other valleys along China's western frontier as there are several records for the adjacent portion of Soviet Kazakhstan (Iverson 1986).

Manouria impressa (Testudo impressa, Geochelone impressa): HAINAN: no locality given. Zong and Ma, 1974. A specimen obtained at the Wildlife Trading Bureau in Haikou in 1964 is preserved in the Shanghai Museum of Natural History. First record for China. YUNNAN: Xishuangbanna. Zhao, 1986. This record is based on an unspecified number of the shells of butchered specimens. First record for mainland China. HUNAN: Shaoyang, at junction of Shao and Yangtze Rivers. Zhao, X., 1986. A photograph and measurements accompany this largely descriptive account of a tortoise found in mid-January, 1986. First provincial record. The remoteness of Shaoyang from the known distribution of this species in extreme southern China, and its having been captured in midwinter argue strongly that the tortoise was an introduction.

Family Trionychidae

Trionyx sinensis: LIAONING: Zhuanghe; Ingkou; Sueizhueng (1 female each); Linguan (2 males, 4 females). Zhao and Huang, 1982. Measurements, dates of capture, and contents of reproductive organs are given for 3 female specimens, CIB 806001-2 and 806016, but which locality they came from is not indicated, nor is what became of the remaining 6 turtles. Iverson (1986) records the species from Shenyang, Liaoning. This species was recorded from the vicinity of Harbin and the Amur River basin in Heilongjiang (Manchuria) by Pavlov (1926). SHAANXI: Luonan. Song and Fang, 1982. Foping Nature Conservation Area: between 610-780 m. Yuan, 1985. The species is well represented in southern and central Shaanxi (Iverson 1986). ANHUI: Puoliangtin Commune, Shushuong Co. Zou, 1983. The lower Yangtze basin is well represented by records for this taxon (Iverson 1986). ZHEJIANG: coastal isles and part of Zhoushan Qundao. Gu et al., 1982. These records are apparently the first for the offshore archipelago. There are numerous records from the adjacent mainland (Iverson 1986). JIANGXI: Anfu; Pingxiang; Longnan (one specimen at each locality collected by the author); Lu shan (literature record). Zhong and Wu, 1981. The literature record, apparently known to Iverson (1986) is hundreds of km N of the other 3 localities.

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A Major Research Achievement in Captive Reproduction of Chinese Alligators

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FIG. 1. Hatchling Chinese Alligator leaving its shell.

The Chinese Alligator (*Alligator chinensis*) is the only species of crocodilian found in China. For various reasons, alligators nearly went extinct in China. By 1979, their range had been reduced to five counties in Xuancheng Prefecture, Anhui Province and the total population was less than 500.

The Anhui Research Center of Chinese Alligator Reproduction was established in 1979 to study the preservation of this species through captive reproduction. In 1981, with the help of Prof. Bihui Chen, we had mastered the techniques of artificial incubation and in 1982 we developed methods for feeding young alligators.

By 1983, only four years after the center opened, both the number of eggs hatching and the survival rate of young alligators reached about 95%. The nesting rate of adult female alligators, which are housed is designed dens, had increased from 14% to 67% with about 90% of the eggs laid being fertile. The male/female sex ratio is 1:6. We are now hatching about 800 alligators each year, and the size of the captive population is increasing rapidly.

Our final goal with the captive breeding program was to complete the egg to egg live cycle at the center. Due to time limitations we were not able to accomplish this goal for a long time. For the last few years, we have paid much attention to the feeding and care of the young alligators hatched in 1982. Special diets were provided and natural habitats were incorporated into the design of the pen. Finally on July 5, 1988, the first nest of 25 eggs was was produced by alligators that had hatched in 1982. After an incubation period of 54 days, a second generation of

FIG. 2. A nest of Chinese Alligator eggs.

FIG.3. Adult and hatchling Chinese Alligators basking.

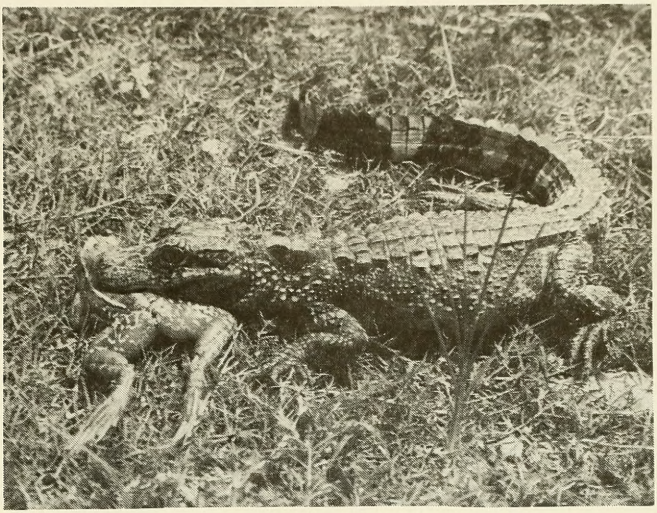

FIG. 4. Four year old Chinese Alligator feeding on a *Rana*.

TABLE 1. Length, weight, and sex of 1982's alligators.

Sex	N	Weight (kg)	Range (kg)	Length (cm)	Range (cm)
Male	4	10.62 ± 2.01	8.5 - 13.5	139.75 ± 6.38	132 - 147
Female	35	8.65 ± 2.06	4.5 - 12.5	130.17 ± 8.10	112 - 146

22 Chinese Alligators hatched.

On September 20, 1988 we examined a sample of 39 alligators from the 1982 population in order to measure their weight and size and to determine sex ratio (Table 1). Chinese Alligators grow slowly and there is considerable variation in weight and size. As in the wild population, the frequency of males is very low. Since only one next was produced this year, it takes at least six years for Chinese Alligators to reach sexual maturity. Most will take seven years and some maybe even longer. In order to produce more second generation alligators, we are going to reduce the density in the rearing areas and remove some smaller individuals.

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